

FIRE HISTORY AND FIRE REGIMES
PAPOOSE ALLOTMENT
NEZ PERCE NATIONAL FOREST

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INTRODUCTION

During the fall of 1997, a fire history assessment was conducted for the Papoose Allotment on the Nez Perce National Forest, central Idaho. The goal was to determine area fire history and fire regimes to help managers design possible strategies for ecosystem management. Specific objectives were to: 1) sample presettlement fire history, 2) model presettlement fire regimes, and 3) document the effects of attempted fire exclusion after 1900.

The study area (3200-8400 ft. elev.) encompasses about 15,000 acres of relatively steep montane- and subalpine forests interspersed with mountain grasslands in the Salmon River Breaks, west of Riggins, Idaho (fig. 1). About 80 percent of the area is forested. Stands on southerly and easterly aspects at low- to middle elevations occur in the ponderosa pine-Douglas-fir cover type (i.e., warm-dry Douglas-fir- and grand fir habitat types [Steele et al. 1981]). Northerly aspects at low- to middle elevations support various combinations of western larch, Douglas-fir, and ponderosa pine (i.e., moderately warm-moderately dry grand fir habitat types). Subalpine forest cover types are lodgepole pine, lodgepole pine-Douglas-fir, or spruce-fir (i.e., cool-dry and cool-moist subalpine fir habitat types).

METHODS

The methods of Arno and Sneek (1977) and Barrett and Arno (1988) were used to sample fire history. Specifically, partial cross-sections were sawn from fire scarred trees, and an increment borer was used to sample fire-regenerated age classes along transects coursed through the study area. At each sample site, forest cover type and habitat type were documented in 375 m² circular plots.

Fig. 1. Papoose study area. *(In main Papoose File)*

Successional trends were documented in the plots by estimating the canopy coverages of each tree species by four d.b.h. classes: 1) seedlings/saplings [0-4 in.], 2) poles [4-12 in.], 3) mature trees [12-30 in.], and 4) old growth trees [30+ in.].

The fire scar- and increment core samples were air-dried and sanded, then analyzed with a 10-20x binocular microscope. Fire year estimates were compiled into stand- and study area master fire chronologies (Romme 1980, Arno and Peterson 1983), as follows. Closely similar scar year estimates were adjusted to those obtained from nearby samples yielding the clearest ring counts. Then stand fire chronologies were produced by listing the estimated fire years and fire intervals for each site (Arno and Peterson 1983). Stand structure was determined by examining the piths of sample trees relative to the stand fire years, to assess whether the stands were even- or uneven aged. Subsequently, the fire year data were organized into a master fire chronology (Romme 1980) for the entire study area, enabling an analysis of coarse-scale fire frequency.

Fire frequency was analyzed for each sample stand, and for the entire study area, as follows. The fire year data were used to calculate: 1) mean fire interval [MFI], 2) fire interval range, and 3) number of years since the last fire. For planning purposes, the first two pieces of data above document the natural range of variability in presettlement fire frequency, for both the stand- and landscape scales. Conversely, the effectiveness of attempted fire exclusion is measured by the years-since-last-fire data.

RESULTS AND DISCUSSION

Sampling at 75 sites produced 137 fire scar cross sections and increment cores from fire-regenerated seral classes. The earliest fire evidence dated from about 1483 A.D.. However, the

relatively continuous portion of the database spans from 1652 to 1936 (fig. 2), because recurrent fires progressively eliminated most earlier fire scar evidence. Fires occurred in virtually every decade between 1600 and 1997 (fig. 2), but the sampling and fire atlas (on file, NPNF) indicate that the 1936 burn was the last important fire in the study area. Consequently, 1936 is considered the start of the fire exclusion period.

The area master fire chronology (Appendix) contains an estimated 95 fires between 1652 and 1936, yielding an area MFI of about three years (fig. 3). That is, a fire occurred somewhere in the 15,000-acre study area an average of once every three years between 1652 and 1936. Estimated intervals between these fires ranged from one to seven years long. These fire frequency estimates may be conservative. Sampling likely cannot detect every small fire in a large study area, especially given the depletion of fire scar evidence over time (Arno 1976, Barrett and Arno 1982). Therefore, because six decades have passed since the last important fire in the study area, the current fire interval is at least 20 times longer than the presettlement MFI. The fire frequency graph also suggests that factors such as early-day grazing (Gruell 1983, Gruell 1985, Arno and Gruell 1983, Arno and Gruell 1986) may have affected fire frequency well before the advent of organized fire suppression. That is, the curve declines steeply after the last major fire, in 1889 (fig. 2). In fact, 1889 was the most severe drought year in the Columbia Basin between about 1670 and 1970 (Graumlich 1987), and likely the worst fire year between 1500 A.D. and the present (Barrett et al. 1997).

Uniform fire frequency in the study area throughout both dry- and wet climatic periods (Karl and Koscielny 1982, Graumlich 1987, Meko et al. 1993, Barrett et al. 1997) suggests that presettlement fires may have been caused by lightning and Indians (Barrett and Arno 1982, Gruell

Fig. 2. Master Fire Chronology
1600-1997 A.D.

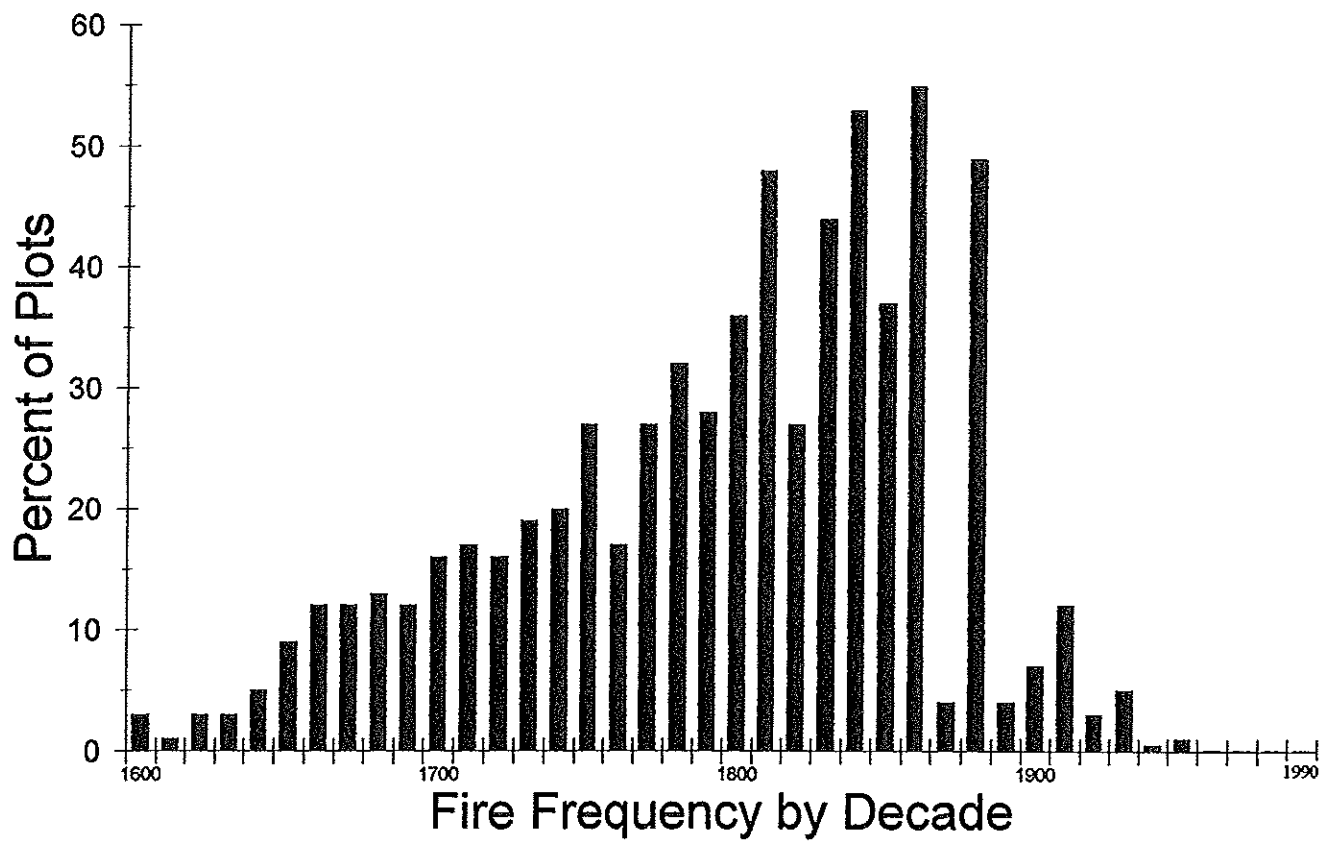
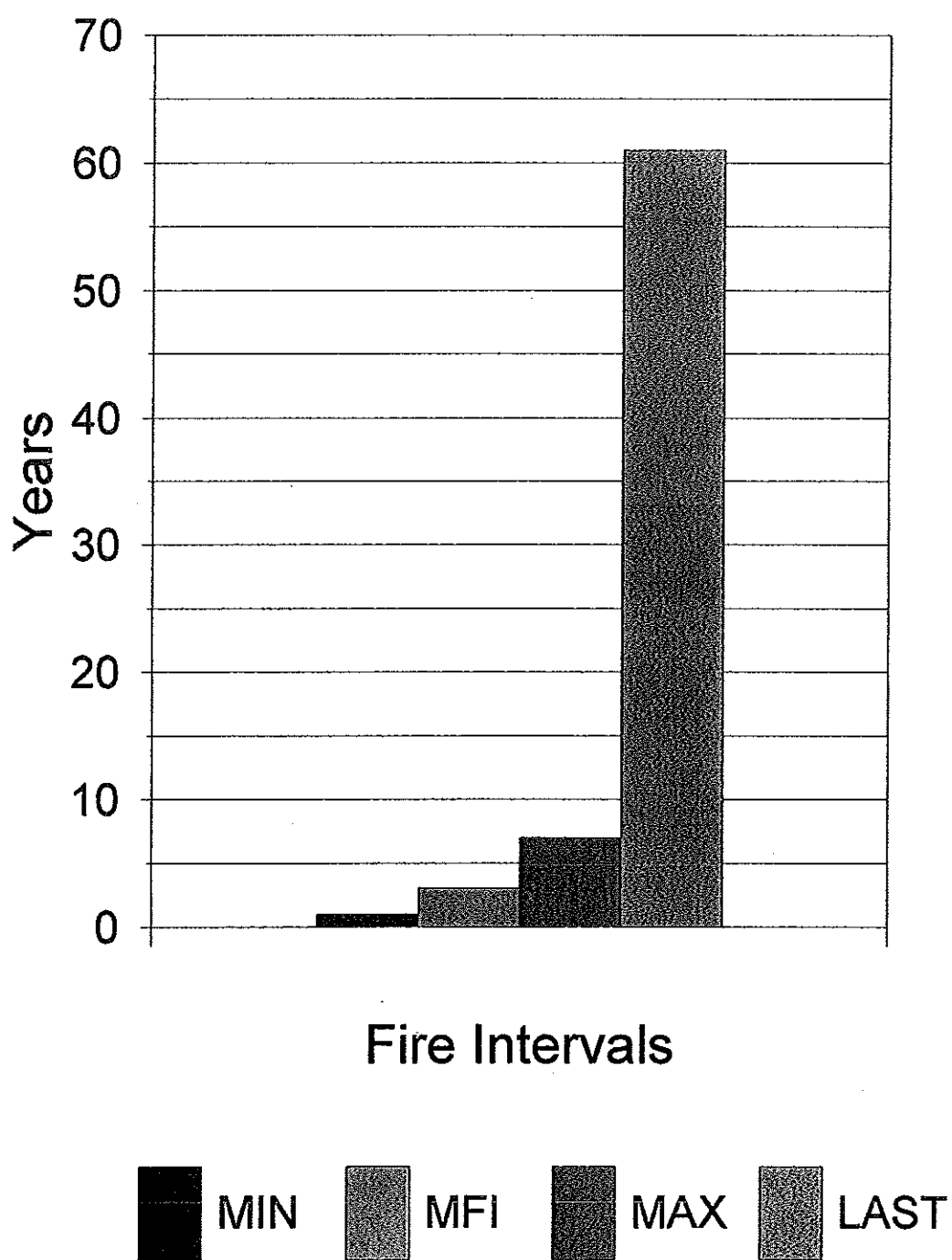


Fig. 3. Historic Fire Intervals vs.
Years Since Last Fire.



1985). By contrast, most fires since 1936 have been quickly suppressed at less than one-quarter acre in size. Based on the presettlement fire frequency, as many as 20 or 30 spreading fires might have occurred — as opposed to only seven fires between 1936 and 1997.

High presettlement fire frequency and advancing forest succession over the last six decades have largely obscured old burn margins. But based on the plot locations, presettlement fires often were limited in extent, or, were light underburns that failed to scar many trees. Eighty-two percent of the fires in the chronology were recorded in eight or fewer (<10%) of the sample plots, which were well distributed throughout the study area. Moderate- to large size fires occurred eight times between the late 1700s and 1889, which is the most complete portion of the chronology. Such fires, recorded in at least 20 percent of the plots, averaged about every 15 years. Two of the largest events, in 1869 and 1889, were represented in 49 percent and 43 percent of the plots, respectively, and may have burned between 50 and 75 percent of the study area. (Note that the term “major fire” relates only to the 15,000-acre study area, which is smaller than some wildfires). Currently, the study area has not experienced a major fire in 108 years — versus the 15-year average interval between 1784 and 1889.

Stand Fire Patterns. Fire scarred trees range from abundant to scarce on any given site, and many stands contain multiple fire-regenerated age classes. This suggests that nonlethal- and mixed severity fires, rather than stand replacing fires, were the predominant severity types (Barrett et al. 1991, Agee 1993, Quigley et al. 1996). Besides the nonlethal fire regime on southerly aspects, two distinct mixed severity fire regimes were found in the study area. That is, different fire frequency- and severity patterns were found in moderately dry- versus subalpine types in the mixed regimes.

Ponderosa Pine-Douglas-fir Stands. Long-term data were obtained from 38 sites

dominated by ponderosa pine (table 1, fig. 4). Nonlethal fires were frequent during the presettlement era, particularly on south slopes supporting widely scattered, uneven age ponderosa pine (e.g., *Psme/Syal-Pipo* h.t.). Presettlement MFIs ranged from eight to 28 years long, and the overall MFI was 16 years (i.e., 38-site mean). Average minimum and maximum fire intervals were seven and 30 years long, respectively. By contrast, the current fire interval averages 106 years long, which is a sevenfold increase over the average presettlement MFI. In the four worst cases, the current fire intervals ranged from 11 to 14 times longer than the presettlement MFI on the same site. The most striking example of fire exclusion comes from Plot 60 near Spotted Horse Mine, in upper Grave Creek (see plot map included with this report). Fires averaged every nine years between 1660 and 1869, but the site has not burned during the past 128 years.

Based on the presettlement patterns, as many as ten or fifteen fires have been precluded from any given site in the ponderosa pine-Douglas-fir cover type since 1900. These findings of heavily impacted fire frequency in ponderosa pine stands are supported by other fire history studies in central Idaho and eastern Oregon (Bork 1984, Bork 1985, Barrett 1988, Maruoka 1994, Barrett 1994a, Barrett 1994b, Heyerdahl and Agee 1996). For example, during a 1984 study in the Frank Church River of No Return Wilderness (Barrett 1988), 90 percent of the ponderosa pine sample stands in the Salmon River Breaks had not burned since 1935 or earlier. However, the Papoose data provide some of the most striking examples of effective fire exclusion in the Inland Northwest. The apparently longer fire exclusion period in Papoose may be attributable to different land use histories. For example, early-day grazing of domestic livestock may have been more prevalent in the lower reaches of the Salmon River canyon (Skovlin and Thomas 1995).

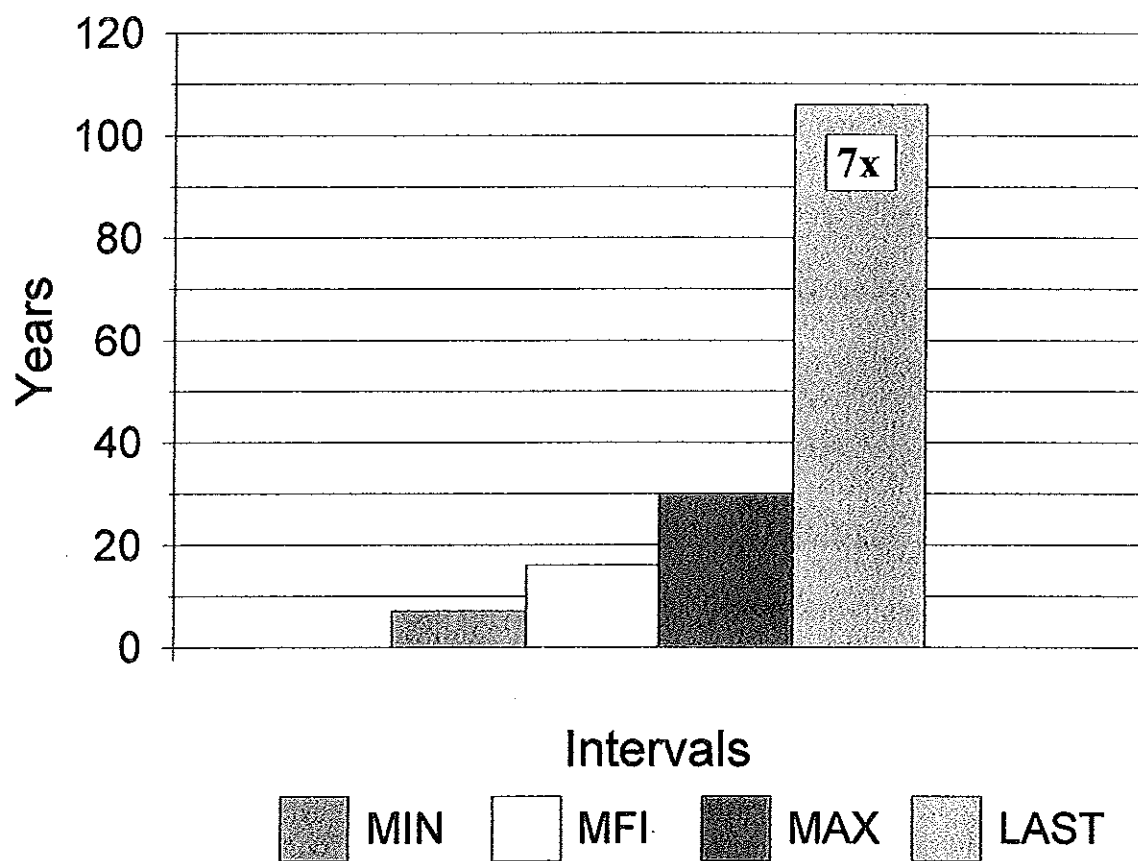
Table 1. Fire frequency- and stand data for 38 sample plots in the ponderosa pine-Douglas-fir cover type (*Nonlethal Fire Regime*).

Plot No. ¹	Hab. Type ²	Asp.	Elev. (ft)	MFC ³	No. Fires	Intvl. Range (yr)	MFI (yr) ⁴	Last Fire ⁵ (yr)
6	Abgr/Spbe	SW	6280	1668-1859	7	12-58	27	138
10	Psme/Syal-Pipo	S	5450	1725-1906	10	5-38	20	91
11	Abgr/Acgl-Phma	SE	5560	1656-1863	12	6-38	19	134
14	Psme/Syal-Pipo	S	5300	1784-1926	18	3-20	8	71
15	Abgr/Acgl-Phma	E	5000	1677-1869	19	3-22	11	128
17	Psme/Phma-Pipo	S	4880	1598-1919	17	6-35	20	78
18	Abgr/Acgl-Phma	N	4520	1675-1949	17	5-51	17	48
19	Abgr/Acgl-Phma	N	4700	1686-1892	12	13-31	19	105
25	Abgr/Acgl-Acgl	NW	4440	1732-1869	7	17-32	23	126
26	Abgr/Acgl-Phma	NW	4120	1732-1904	11	7-35	17	93
27	Psme/Syal-Pipo	S	3960	1803-1889	7	5-26	14	108
28	Psme/Syal-Pipo	SW	4360	1806-1889	4	20-39	28	108
29	Psme/Syal-Pipo	SW	4500	1756-1910	15	3-26	11	87
30	Psme/Syal-Pipo	SE	4480	1803-1889	6	6-32	17	108
31	Abgr/Acgl-Phma	NW	4520	1714-1889	13	6-34	15	108
32	Psme/Phma-Pipo	W	4420	1697-1889	8	8-54	27	108
34	Abgr/Acgl-Phma	N	4500	1747-1889	10	5-22	16	108
35	Psme/Phma-Pipo	N	4220	1809-1889	10	2-20	9	108
36	Psme/Phma-Pipo	N	4030	1790-1889	9	7-20	12	108
37	Abgr/Acgl-Phma	NW	4080	1797-1869	7	7-22	12	128
38	Psme/Cage-Pipo	NE	3960	1775-1889	15	3-24	8	67
39	Abgr/Acgl-Phma	NE	3480	1686-1869	11	5-34	19	128

Plot No. ¹	Hab. Type ²	Asp.	Elev. (ft)	MFC ³	No. Fires	Intvl. Range (yr)	MFI (yr) ⁴	Last Fire ⁵ (yr)
40	Abgr/Acgl-Phma	SW	5200	1803-1910	6	8-42	21	87
46	Psme/Phma-Pipo	SE	4300	1598-1910	20	5-42	16	87
52	Abgr/Libo-Libo	NE	4880	1765-1906	10	3-37	16	91
53	Psme/Phma-Pipo	S	3920	1775-1889	7	16-28	19	108
60	Psme/Phma-Pipo	SW	5760	1660-1869	24	4-25	9	128
61	Abgr/Vagl	E	5440	1803-1869	4	13-29	22	128
62	Abgr/Acgl-Phma	SW	5160	1756-1859	6	5-27	21	138
64	Psme/Phma-Pipo	S	5160	1642-1910	26	5-24	11	87
65	Psme/Syal-Pipo	SW	4950	1642-1889	22	7-18	12	108
66	Psme/Syal-Pipo	SE	4760	1768-1889	12	3-20	11	108
67	Psme/Phma-Pipo	SE	4680	1664-1889	15	5-34	16	108
69	Abgr/Acgl-Phma	SE	4350	1756-1889	8	9-29	19	108
70	Psme/Phma-Pipo	S	4300	1796-1889	9	5-20	12	108
71	Abgr/Acgl-Phma	E	4400	1719-1884	17	3-20	10	113
73	Psme/Phma-Pipo	W	4600	1784-1889	8	11-20	15	108
75	Abgr/Acgl-Phma	NE	4250	1664-1889	18	5-26	13	108
Range:				3480-6280	1598-1949	6-26	2-58	8-28
Mean:				4655	-	12	7-30	16
							8-28	48-138
							16	106

1. Locations on study area map (on file, NPNF).
2. Habitat type acronyms follow Steele et al. (1981).
3. Stand Master Fire Chronology.
4. Mean Fire Interval.
5. As of 1997.

Fig. 4. Avg. Fire Intervals for PP
Nonlethal Fire Regime (n=38 plots)



Montane Mixed Conifer Stands. Data were obtained from 23 sites dominated by various mixes of conifers in the area's moderately warm-moderately dry habitat types (e.g., larch-Douglas-fir stands in *Abgr/Clun* and *Abgr/Vagl*)(table 2, fig. 5). Such stands are found at mid- to upper elevations in the study area, largely on northerly aspects. Mixed severity fires were often comparatively frequent before 1936, burning at low- to moderate intensities that produced multiple even-age classes in many stands (i.e., seral component). However, the site MFIs ranged widely, from about 30 years to 102 years long, and the overall MFI was 52 years. Average minimum- and maximum fire intervals were 25 and 92 years long, respectively. By contrast, current intervals range from 61 to 242 years long, and the overall mean of 131 years since the last fire represents about a threefold increase over the average MFI. Based on the presettlement fire patterns, from one to five fires have been precluded from a given stand in the mixed conifer cover type. This pattern of moderately frequent mixed severity fires, followed by effective fire exclusion, has been found elsewhere in central Idaho and eastern Oregon (Barrett 1987, Barrett 1994b, Heyerdahl and Agee 1996). In the adjacent Rapid River drainage, for example, presettlement fires averaged about every 56 years in five larch-Douglas-fir sample stands (Barrett 1987). However, prior to recent wildfires and several manager-ignited fires, the Rapid River drainage had not burned since the early 1900s.

Old larches and Douglas-firs rarely had more than three scars each, whereas ponderosa pines on dry sites in the nonlethal regime often had 10 or more scars per tree. Also attesting to relatively severe fires in mixed conifer stands, most stands have few veterans older than 200 years, whereas ponderosa pines often range from 300 to 500 years old. However, fire severities in the mixed conifer stands ranged from creeping underburns to partial- or total stand replacement on any given site. As a

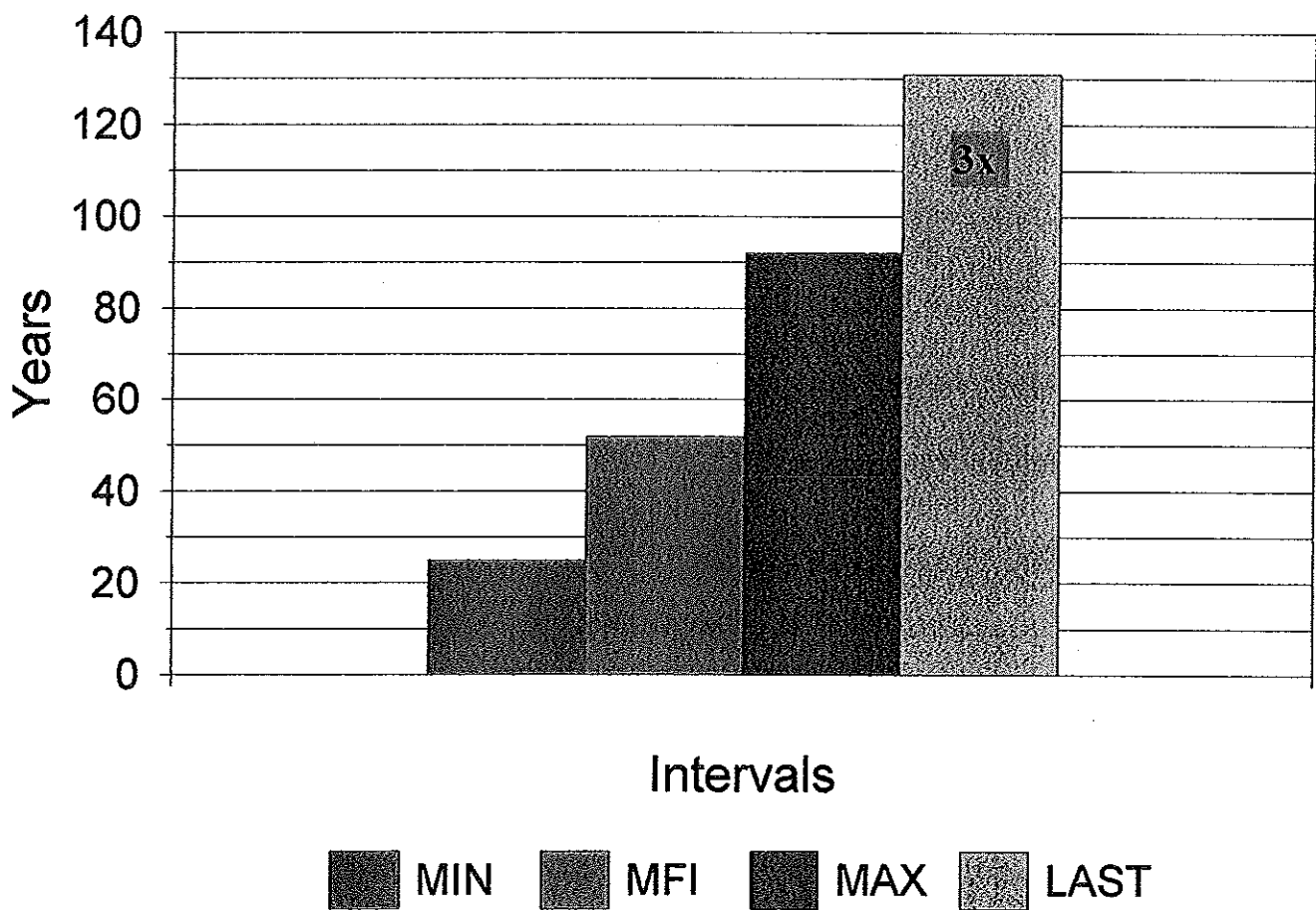
Table 2. Fire frequency- and stand data for 23 sample plots in the montane mixed conifer cover type (e.g., Larch-DF) (*Mixed Severity I Fire Regime*).

Plot No. ¹	Hab. Type ²	Asp.	Elev. (ft)	MFC ³	No. Fires	Intvl. Range (yr) ⁶	MTF ⁴ (yr)	Last Fire ⁵ (yr)
9	Abgr/Acgl-Acgl	SW	6150	1656-1809	4	25-100	51	188
12	Abgr/Vagl	NE	6260	1697-1869	6	6-87	34	128
13	Abgr/Vagl	NE	5400	1830-1936	1	106+	-	167
16	Abgr/Clun	S	4000	1784-1919	4	12-70	45	78
20	Abla/Vagl-Vagl	NW	6200	1756-1936	1	181+	-	241
21	Abgr/Vagl	E	6240	1700-1852	3	40-111	76	145
22	Abgr/Vagl	NE	6200	1830-1936	1	106+	-	167
23	Abgr/Vagl	N	5960	1784-1919	2	135	-	78
24	Abgr/Acgl-Acgl	SE	6000	1772-1919	4	40-57	49	78
41	Abgr/Acgl-Acgl	E	5480	1772-1889	5	9-64	29	108
42	Abgr/Spbe	SE	6400	1686-1889	3	42-161	102	108
44	Abla/Caru	SE	7150	1756-1889	4	23-91	44	108
45	Abla/Caru	S	7150	1772-1866	3	19-69	47	131
47	Abgr/Libo-Libo	E	4680	1803-1889	2	86	-	108
48	Abgr/Clun	NE	4750	1483-1936	6	26-135	91	61
49	Abgr/Clun	SE	5880	1784-1866	3	19-63	41	131
50	Abla/Xete/Vagl	E	6300	1784-1847	2	63	-	150

Plot No. ¹	Hab. Type ²	Asp.	Elev. (ft)	MFC ³	No. Fires	Intvl. Range (yr) ⁶	MFI ⁴ (yr)	Last Fire ⁵ (yr)
54	Abgr/Vagl	NE	5600	1803-1936	1	133+	-	194
55	Abla/Caru	SE	6810	1827-1889	2	62	-	108
59	Abgr/Vagl	S	5800	1741-1869	5	7-80	32	128
63	Abgr/Libo-Vagl	NE	5280	1756-1815	2	59	-	182
68	Abgr/Libo-Libo	N	4720	1775-1893	5	23-37	30	104
72	Abgr/Libo-Vagl	N	4600	1796-1889	3	30-63	47	108
				Range: 3480-6280	1598-1949	1-6	6-181	29-102
				Mean: 5782	-	3	25-92	52
								61-242
								131

6. "+" denotes interval as of 1936 (Fire Exclusion Period).

Fig. 5. Avg. Fire Intervals for WL-DF
Mixed Severity I Regime (n=23 plots)



result, such stands contain more species- and structural diversity than in the ponderosa pine type.

Subalpine Stands. Data were obtained from 11 sites in the subalpine forest zone (e.g., *Abla/Vagl*, *Abla/Caru* h.t.s)(table 3, fig. 6). Mixed severity fires were often less frequent and more severe, including occasional stand replacing fires. Minimum- and maximum fire intervals in the 11 stands ranged widely, from 30 to 240 years long, respectively. However, site MFIs ranged from 80 to 130 years long, and the overall MFI was 108 years. By contrast, the current fire intervals range from one to 213 years long. The overall mean of 124 years since the last fire is only slightly longer than the average MFI, suggesting that most subalpine stands are still within the range of presettlement variability. That is, because presettlement fire intervals were often longer than those produced by the fire exclusion period to date, this cover type has been less affected by fire exclusion. Nonetheless, an overall lack of early successional stands suggests that future fires occurring in this forest zone will likely trend toward the severe end of the spectrum. This interpretation is supported by the results of a wildfire in 1996 that barely entered the northern portion of the study area from the adjacent Hells Canyon NRA. The fire burned in a total stand replacement pattern in lodgepole pine along the Salmon-Snake River divide.

Similar results were obtained for subalpine stands in the Bear Analysis Area near Council, Idaho, on the Payette National Forest, (Barrett 1994b). Three sites yielded an average MFI of 76 years for mixed severity fires during the presettlement era, versus a current fire interval of 101 years.

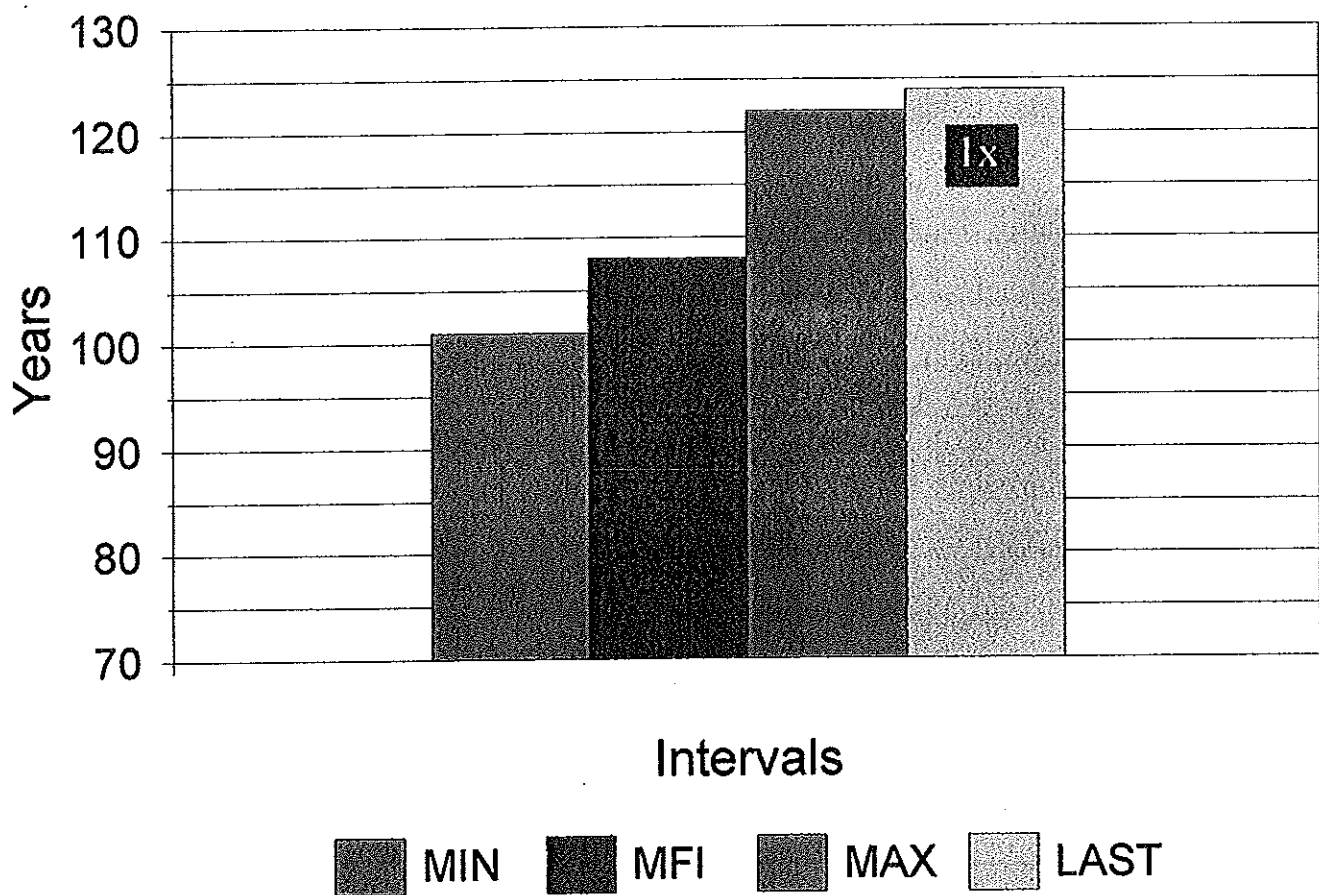
Fire Patterns at the Landscape Scale.

Presettlement Period. The study area age class mosaic, generated by at least 100 fires over the last 350 years, is highly complex. Succession during the six-decade long fire exclusion

Table 3. Fire frequency- and stand data for 11 sample plots in the subalpine forest zone (e.g., LPP c.t.) (*Mixed Severity II Fire Regime*).

Plot No. ¹	Hab. Type ²	Asp.	Elev. (ft)	MFC ³	No. Fires	Intvl. Range (yr) ⁶	MFI ⁴ (yr)	Last Fire ⁵ (yr)
1	Abla/Xete-Vasc	E	7000	1803-1936	1	133+	-	194
2	Abla/Caru	SE	6900	1677-1847	2	170	-	150
3	Abla/Xete-Vagl	SE	6560	1869-1889	2	20	-	108
4	Abla/Xete-Vagl	S	6500	1869-1936	1	67+	-	128
5	Abgr/Xete-Vagl	SE	6480	1691-1859	2	168	-	138
7	Abla/Vagl-Vagl	NE	6200	1564-1830	3	28-238	133	167
8	Abla/Vagl-Vagl	E	6240	1859-1936	1	77+	-	138
51	Abla/Vagl-Vagl	N	6880	1784-1936	1	152+	-	213
56	Abla/Caru	E	6650	1827-1936	1	109+	-	1
57	Abla/Caru	E	7120	1827-1936	2	109	-	61
58	Abla/Caru	NE	7350	1772-1936	3	73-91	82	61
Range: 6200-7350				1564-1936	1-3	28-238	82-133	1-213
Mean: 6716				-	2	101-122	108	124

Fig. 6. Avg. Fire Intervals for LP-DF
Mixed Severity II Regime (n=11 plots)



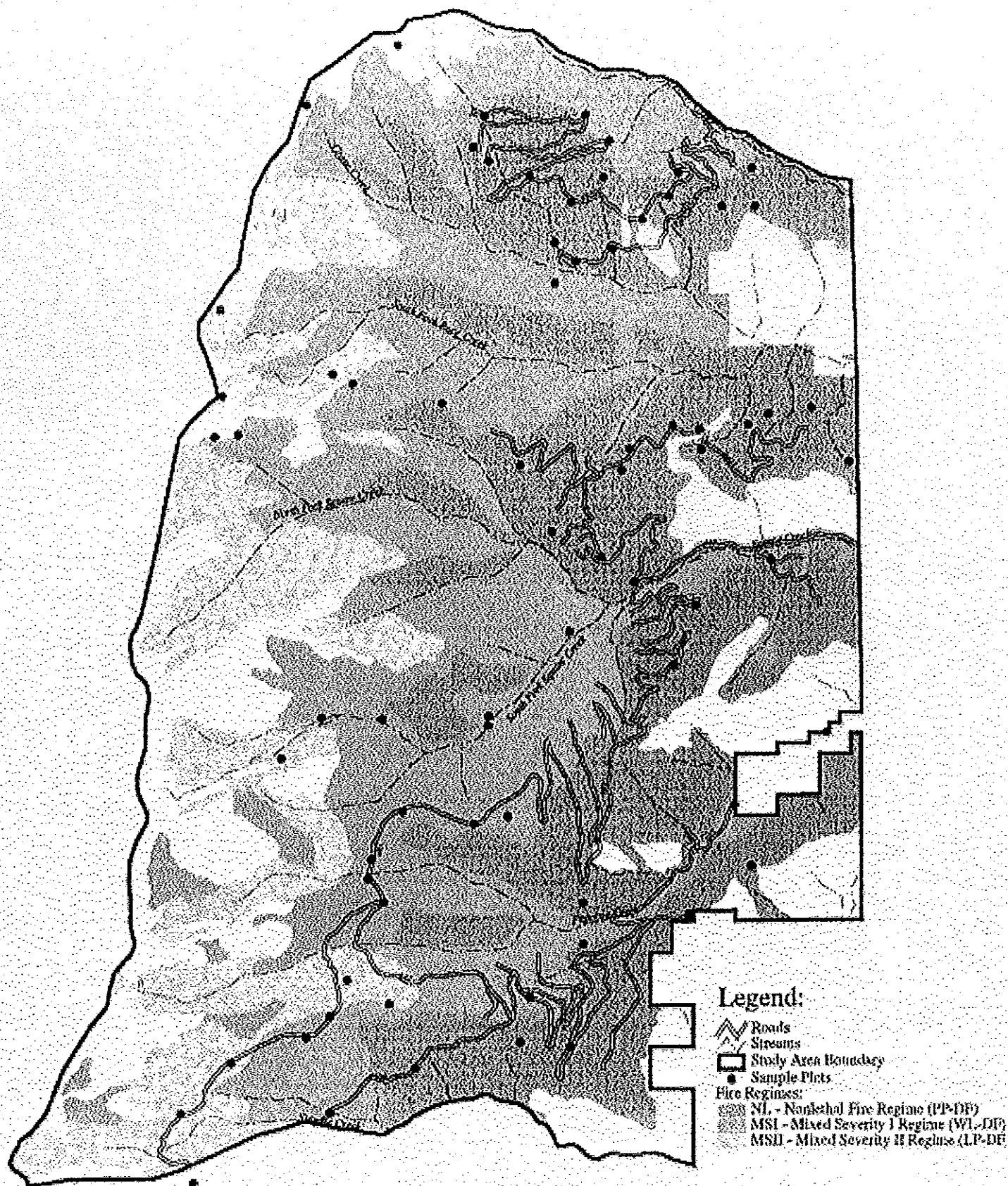
period, and timber harvesting, have further masked old burn margins. Therefore, rather than mapping stand origins (Heinselman 1973, Barrett et al. 1991), the fire history data were used to model the areal extent of the three fire regime types (fig. 7). Ecologically similar habitat types (on file, NPNF Geographic Information System [GIS]) and the fire history data were used to stratify the study area by forest cover type and associated fire regime type. Ponderosa pine-Douglas-fir stands, occupying most aspects at low elevations and shifting to southerly aspects at mid elevations, were assigned to the *high frequency/low severity* (Nonlethal) fire regime. Adjacent montane mixed conifer stands, typically in riparian zones at low elevations and shifting to northerly aspects at mid elevations, were assigned to the *moderately high frequency/low to moderate severity* (Mixed Severity I) presettlement fire regime. Finally, stands in the subalpine zone were classified as the *moderately low frequency/moderate to high severity* (Mixed Severity II) fire regime.

The model (fig. 8) suggests that 44 percent of the stands in the study area had a nonlethal fire regime during the presettlement era (i.e., *PP-DF* c.t.). Thirty-eight percent occur in the Mixed Severity I presettlement fire regime, that is, montane mixed conifer stands (e.g., *WL-DF* c.t.). The remaining 18 percent of the stands occur in the Mixed Severity II presettlement fire regime, largely in the subalpine zone (i.e., *LP* c.t.).

Fire Exclusion Period. After the fire regimes were modeled, a fire exclusion map was developed for the study area. The objective was to interpret the effectiveness of fire exclusion at the landscape scale, by determining an average “fire exclusion factor” for all stands. First, data from the fire atlas and sample stands were used with aerial photographs to map the approximate boundaries of the last fires in each drainage. Because fire margins are now obscure, most polygons were labeled by

Fig. 7. Area fire regimes. (Map).

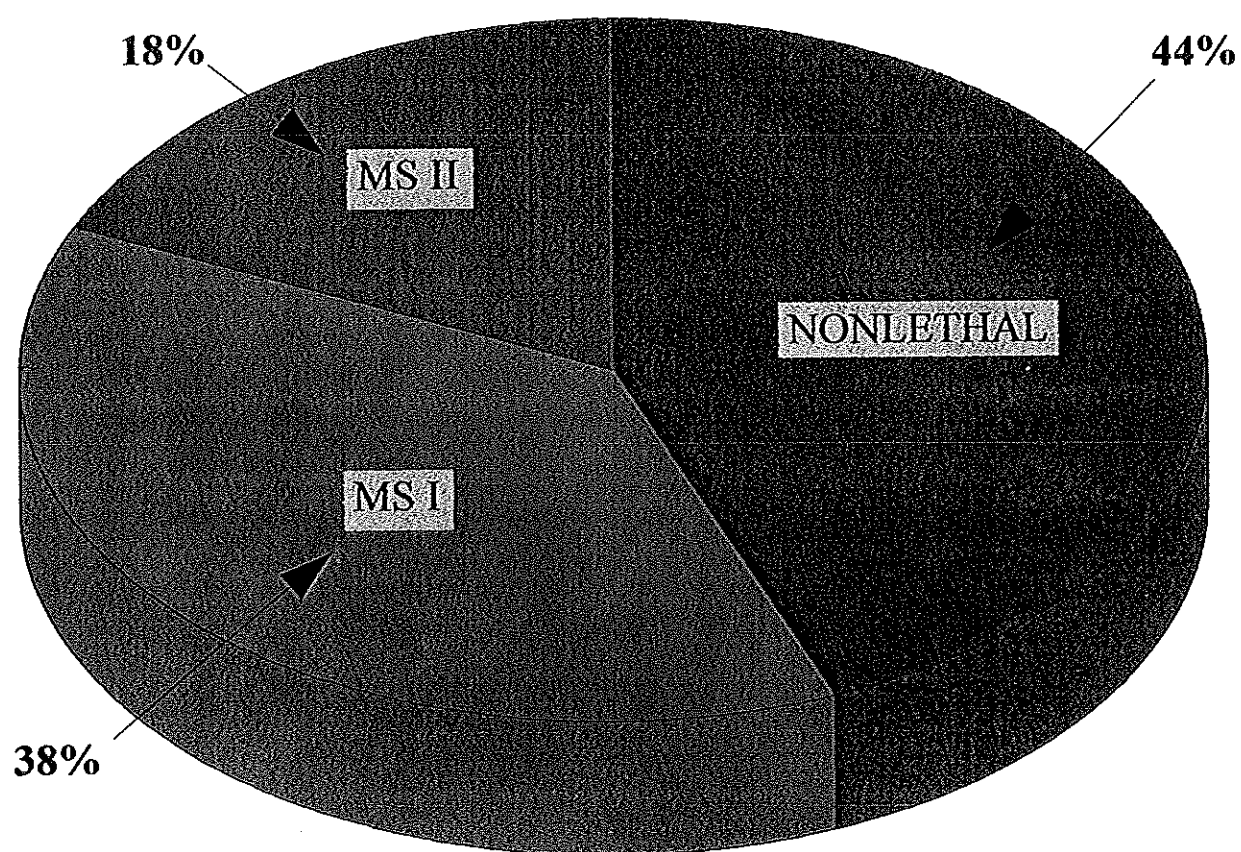
Fig. 7. Area Fire Regimes



0.5 0 0.5 1 Mile
1:50,000



Fig. 8. Area Fire Regimes
Papoose Allotment, Nez Perce NF



fire period rather than by fire year (e.g., "1889-1919"). These polygons were then superimposed on the fire regimes map to determine an average fire exclusion factor for each drainage. For example, the current fire interval for most stands in the lower Papoose Creek drainage is about 93 years long (i.e., 1889-1919 period midpoint). For the nonlethal fire regime, dividing the 93-year long current fire interval by the 16-year average presettlement MFI yields an average fire exclusion factor of six (i.e., a 500% increase in interval length). By contrast, the fire exclusion factor equals two for adjacent mixed conifer stands in the riparian zone (i.e., $93/52 = 2x$). Therefore, results for the lower Papoose drainage suggest that the ponderosa pine fire cycle is seriously out of balance, whereas the mixed conifer stands are still within the range of natural variability.

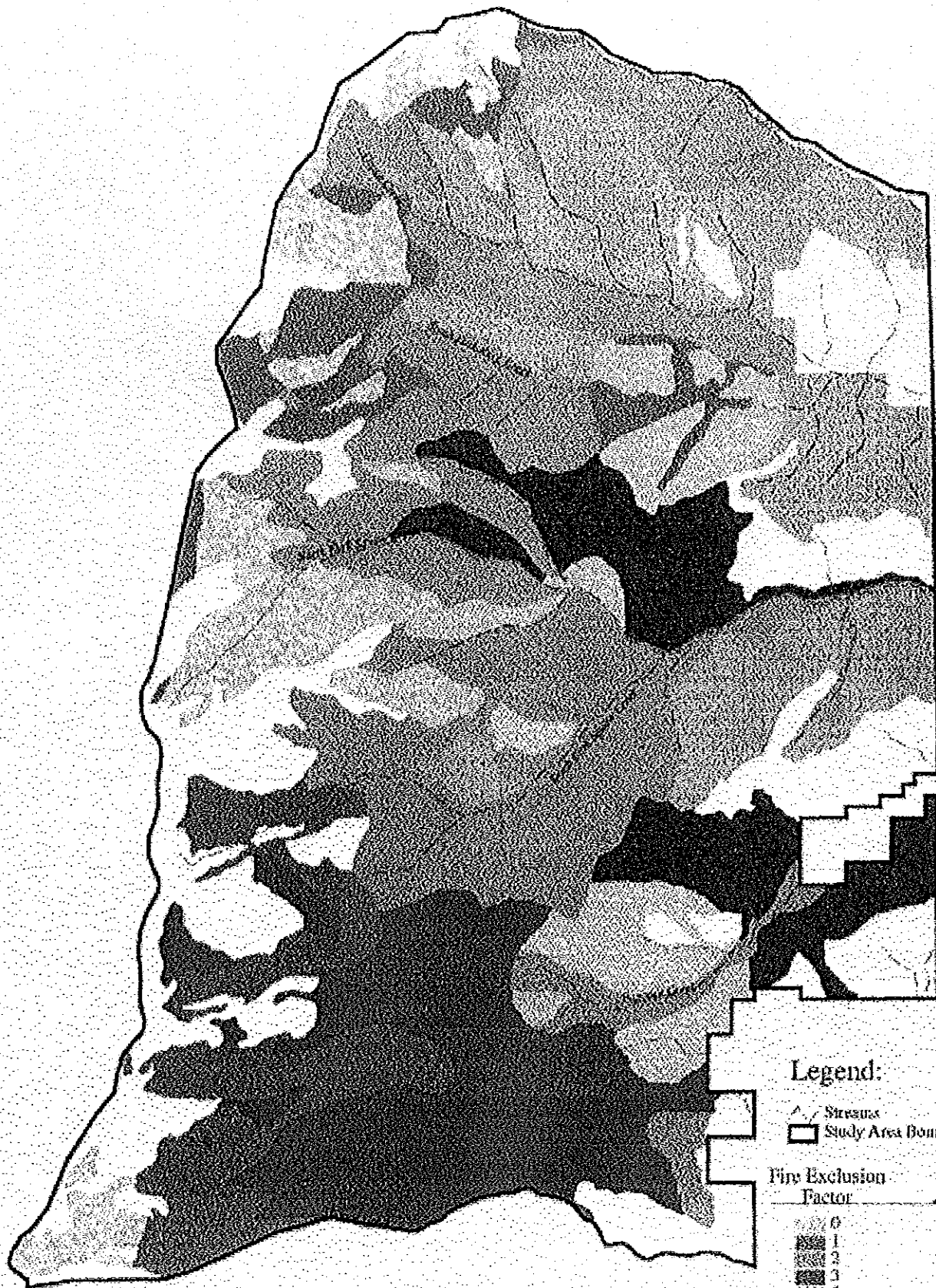
The GIS produced the following results (fig. 9). Thirty percent of all stands have current fire intervals that are roughly equal to or less than the average presettlement MFI. These stands occur in the montane mixed conifer- and subalpine zones, largely in mid- to upper elevation terrain. Specifically, about one-third of the mixed conifer stands and 100 percent of the subalpine stands have fire cycles that are still in balance when compared to pre-1900 MFIs.

About 49 percent of the stands in the study area have current fire intervals that are still within the range of natural variability, as defined by the maximum lengths of the presettlement fire intervals. However, only about 2 percent of the stands in the nonlethal regime fall under this category, as opposed to 78- and 100 percent of the mixed conifer and subalpine stands, respectively. Stand fire cycles in the remaining 51 percent of the study area are substantially out of balance.

The fire exclusion model also yielded the following results for each fire regime type (figs. 10-12). In the nonlethal regime (fig. 10), 98 percent of all ponderosa pine stands have current fire

Fig. 9. Fire Exclusion Map.

Fig. 9, Fire Exclusion Map



Legend:

- Stream
- Study Area Boundary

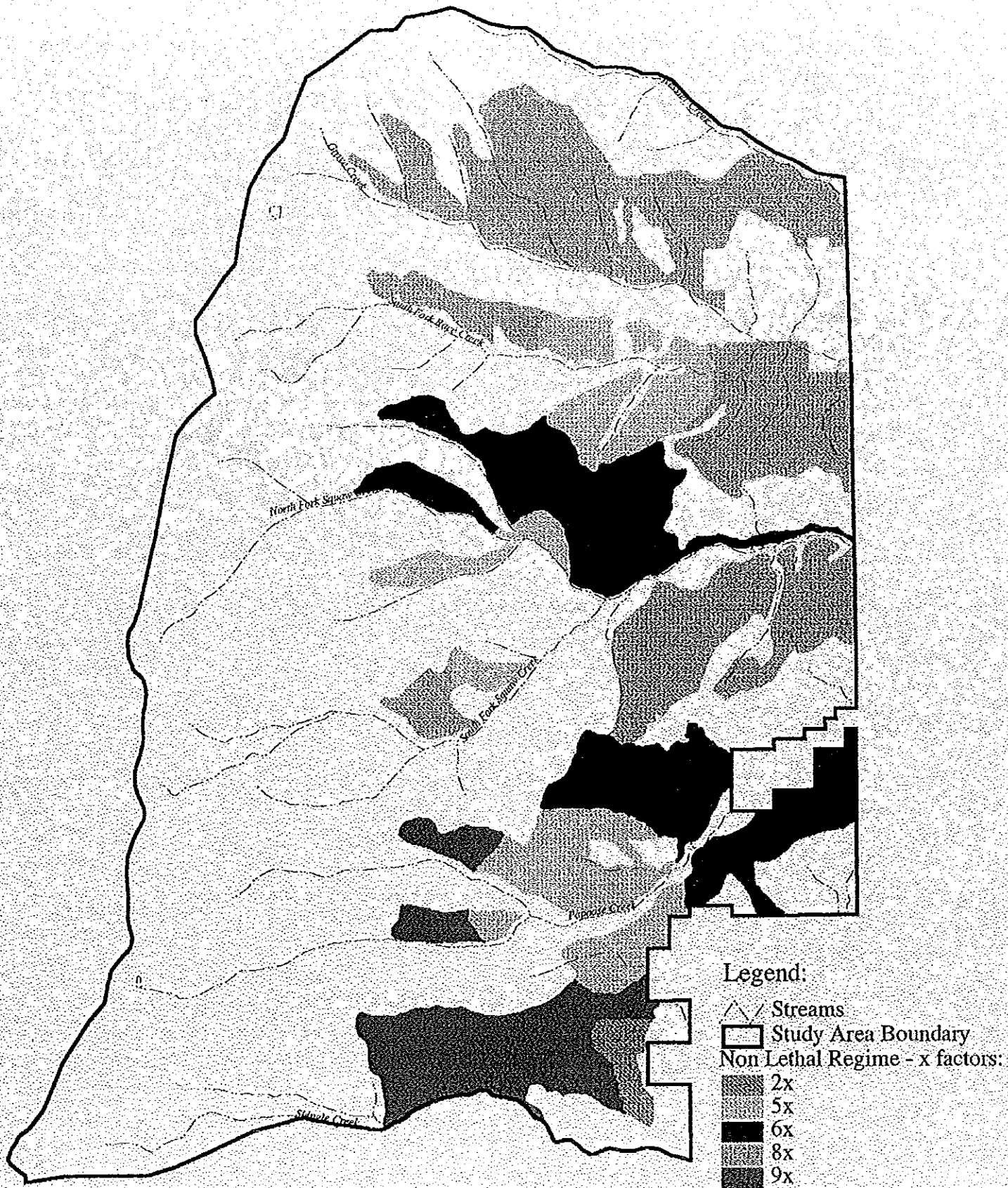
Fire Exclusion Factor	Acres	% Total
0	1182	7%
1	1695	11%
2	3751	24%
3	1066	7%
5	910	6%
6	1200	8%
8	2164	14%
9	663	4%
Non Forested	2847	18%

0 50 100 150 Feet
1:50000



Fig. 10. Fire Exclusion Map: Nonlethal Regime.

Fig. 10. Fire Exclusion Map: Nonlethal Regime



0.5 0 0.5 1 MHz

1:50688



intervals that range from five to nine times longer than the average presettlement MFI of 16 years. This poses a serious problem for management, because the nonlethal regime occupies nearly half the forested terrain in the study area (i.e., 5500 acres). (Note, however, that timber harvesting and associated prescribed burning have occurred on about one-third of this acreage). Twenty-two percent of the stands in the montane mixed conifer type (i.e., 1021 acres) are substantially out of balance, with current fire intervals averaging 200 percent longer than the average MFI of 52 years (fig. 11). Such mixed conifer stands usually adjoin the heavily impacted ponderosa pine zone, raising the risk of unnaturally large and uncharacteristically severe fires carrying from low to high elevations in the study area. None of the stands in the subalpine zone have current fire intervals longer than the presettlement MFI of 108 years (fig. 12). However, fire intervals for half the acreage occupied by these stands (i.e., 1200 ac.) are now equal to the historic mean, suggesting that such stands are now well able to burn.

In terms of location, stands with the most heavily impacted fire cycles are well distributed throughout the study area (fig. 7). But since timber harvesting has diversified much of the lower elevation forest mosaic, the mid- to upper elevation stands currently represent the largest expanses of homogeneous fuels. Stands in the Kessler- and South Fork Race Creek drainages have some of the longest current fire intervals of any stands in the study area. However, most unharvested ponderosa pine stands in the study area are experiencing late post-fire succession.

Successional Trends. Plots at the 75 sample sites were used to document pre- and post-1900 successional trends. These data suggest that fire exclusion has markedly altered stand structure and species composition in most ponderosa pine-dominated stands, particularly on relatively productive sites. Frequently burned stands were dominated by widely spaced, fire-resistant ponderosa pines (figs.

Fig. 11. Fire Exclusion Map: Mixed Severity I Regime.

Fig. 11. Fire Exclusion Map: Mixed Severity I Regime

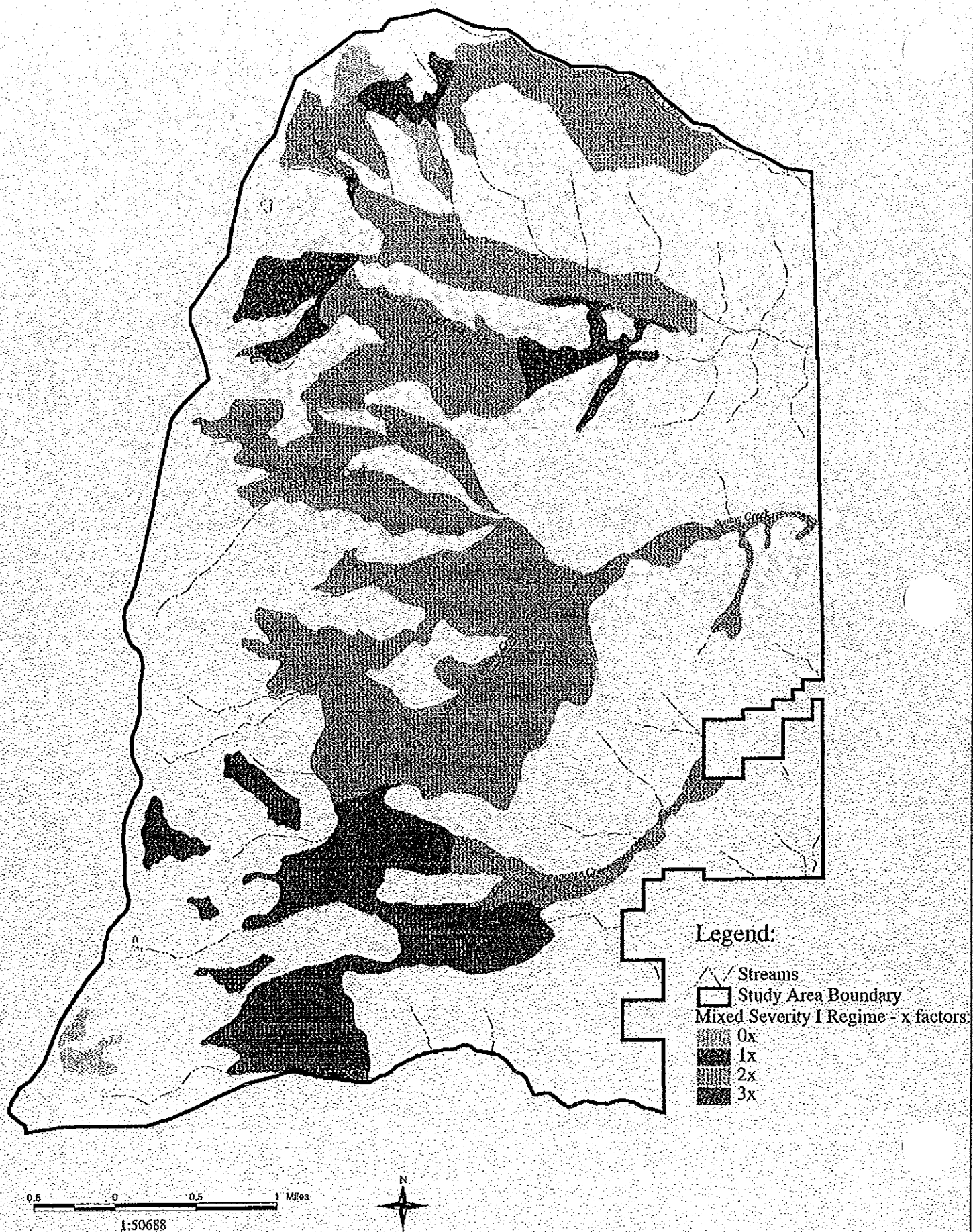
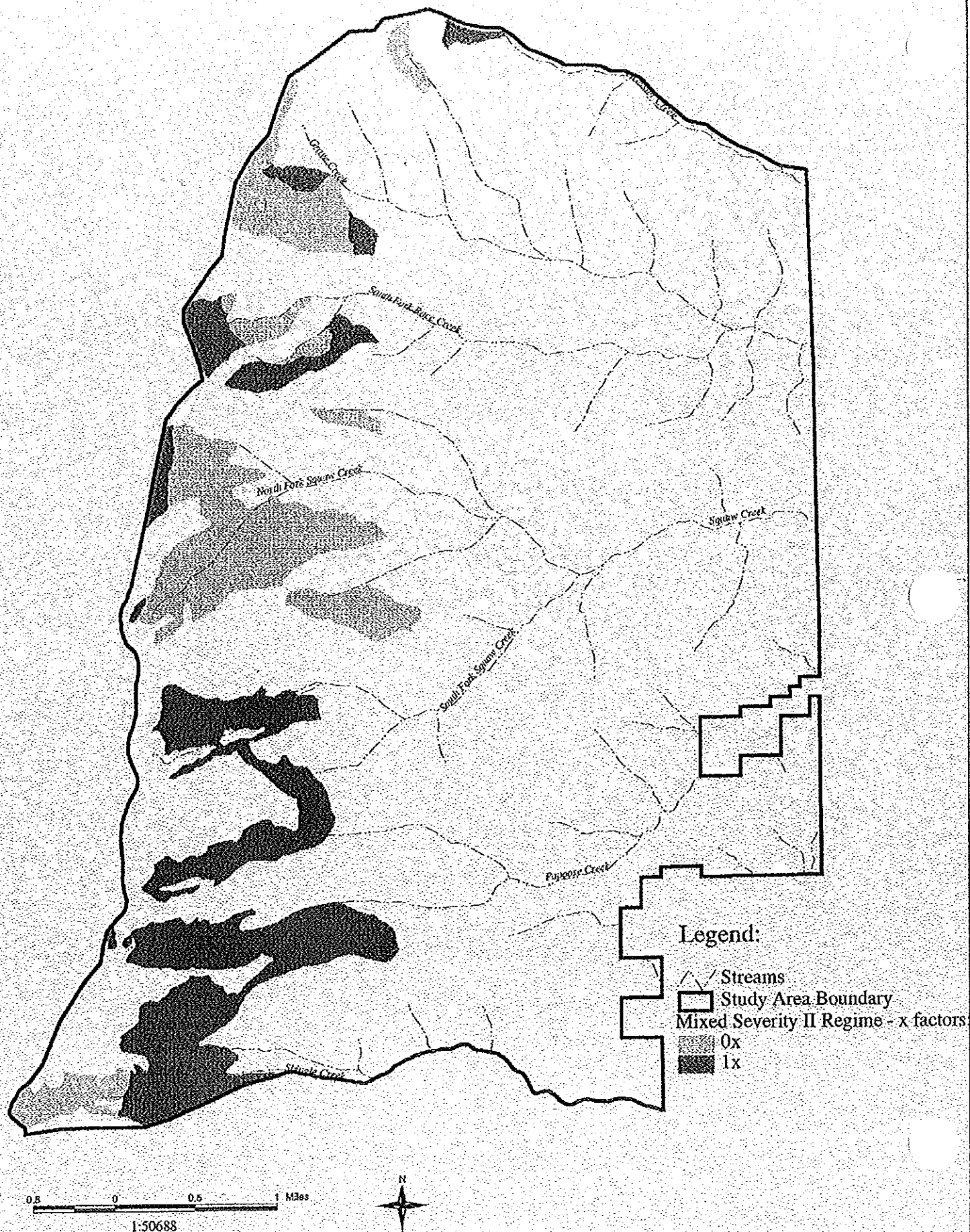


Fig. 12. Fire Exclusion Map: Mixed Severity II Regime.

Fig. 12. Fire Exclusion Map: Mixed Severity II Regime



13, 14). However, long-term fire exclusion has promoted canopy closure and increasingly heavy dominance by shade tolerant species such as Douglas-fir and grand fir. Many unharvested stands are now highly decadent due to overstocking, mistletoe infections, and bark beetle attacks. Root rot pockets and heavy downfalls are also common in the montane mixed conifer stands. Consequently, downed fuels combined with thickets of understory ladder fuels have also promoted a shift in fire potential, from mixed severity- to stand replacement fires (Agee 1993).

Ponderosa pines in the study area often likely regenerated after fires during warm-dry climatic periods (Karl and Koscielny 1982, Graumlich 1987, Meko et al. 1993, Barrett et al. 1997). Conversely, even-age larch- or lodgepole pine age classes often became established after relatively severe fires in the early- to mid-1800s, during the height of the cool-moist Little Ice Age. Despite a subsequent return to a warm-dry climate, few ponderosa pines have regenerated on productive sites in the grand fir series during the last 100 years (e.g., *Abgr/Acgl-Phma* h.t.). Dense regeneration occurred on some north-facing slopes near lower timberline after the 1889 fire, followed by total fire exclusion. Most members of that age class are now heavily overcrowded and some have succumbed to bark beetles — due in part to a lack of thinning fires after initial establishment. Plot 35 in lower South Fork Race Creek drainage provides a striking example of heavy infilling during the fire exclusion period (fig. 13). During the presettlement era, underburns averaged every nine years, but have not occurred for the past 108 years (i.e., in 1889). Previously, the site was dominated by just five to 20 mature ponderosa pines per acre before 1900, as opposed to 500+ Douglas-firs per acre at present. These data indicate that the pre-1900 stand was essentially a pine savannah, in stark contrast to today's heavily closed forest.

Fig. 13. Successional Trends
Ponderosa Pine Savannah (NL Regime)

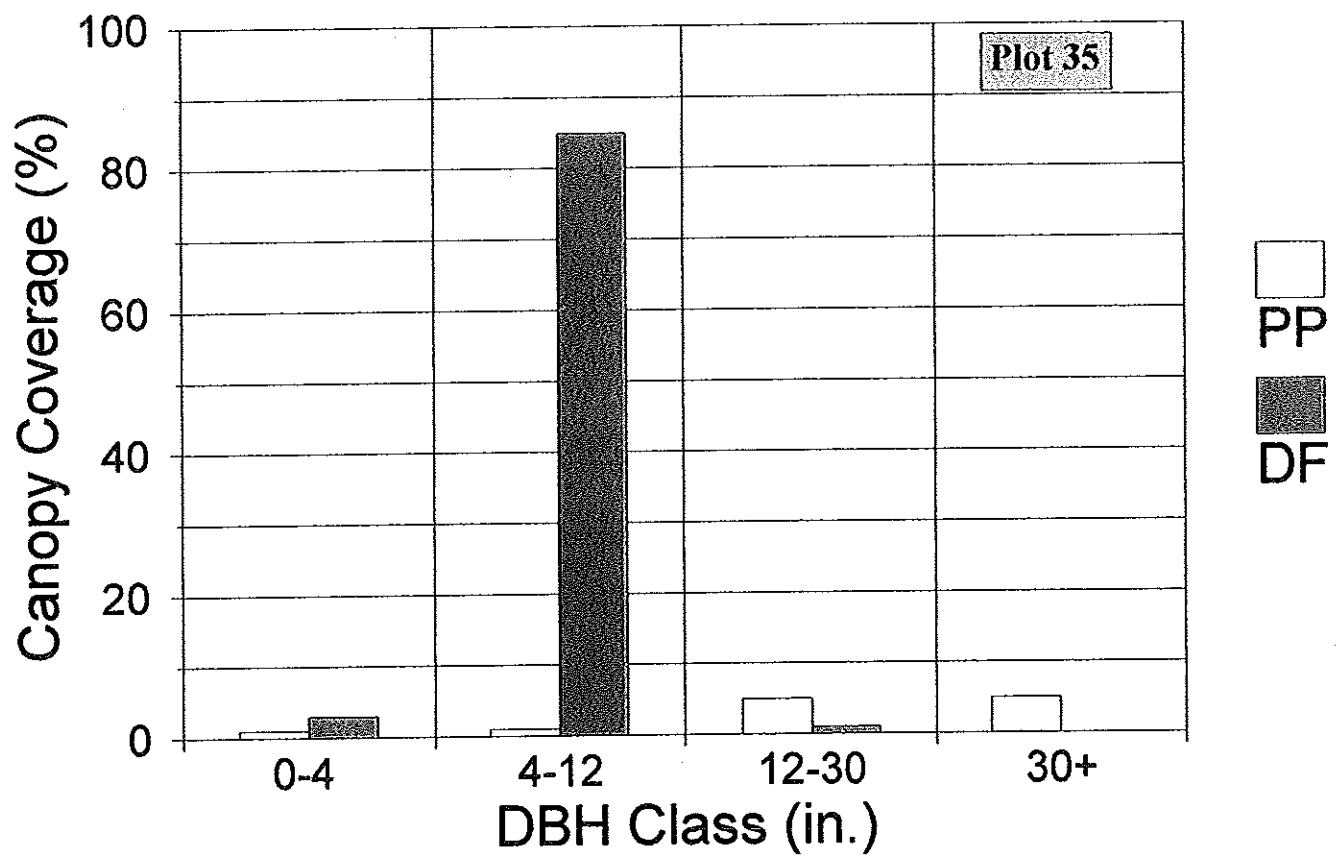
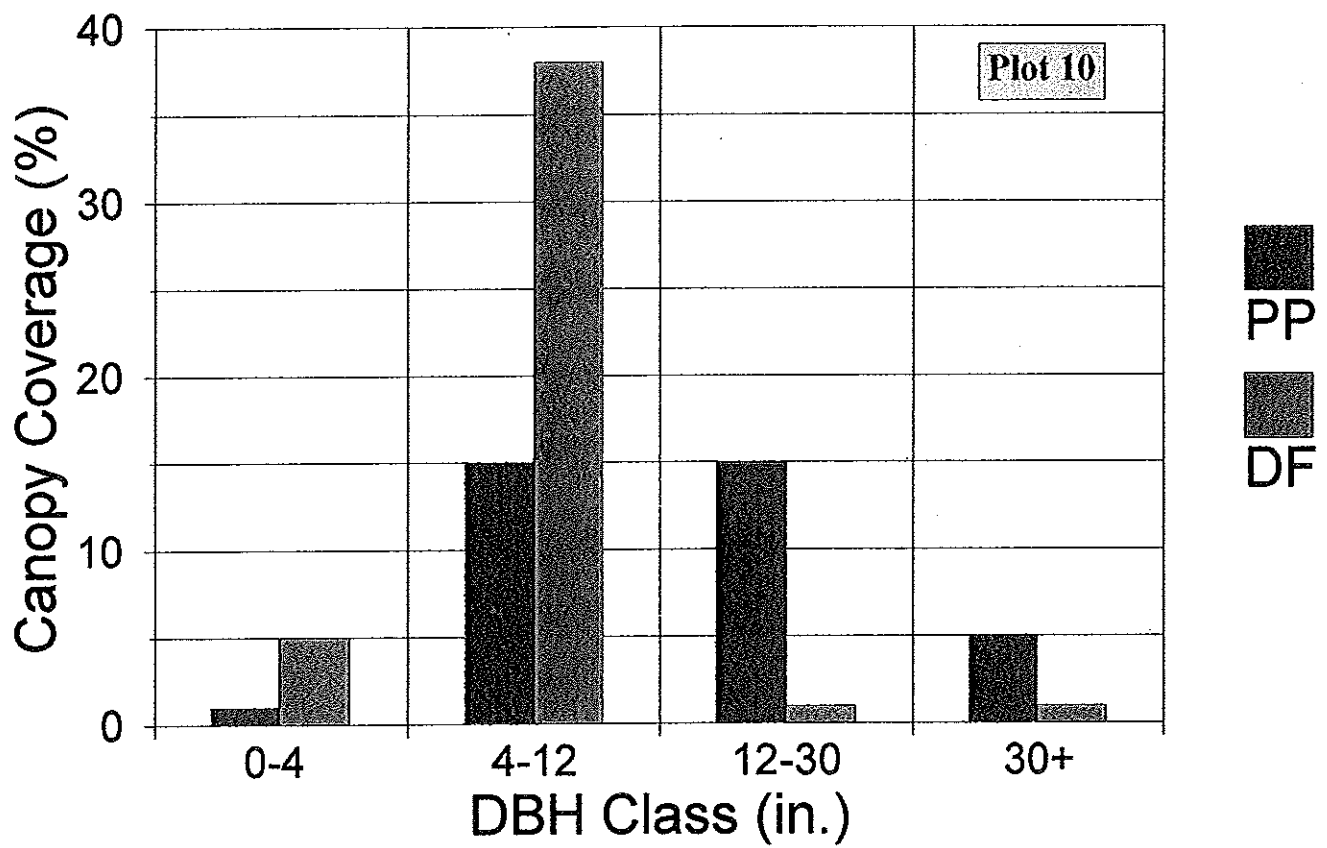


Fig. 14. Successional Trends
PP-DF Cover Type (NL Regime)



The effects of fire exclusion are often less apparent on dry southerly aspects (e.g., *Psme/Phma-Pipo* h.t.) (fig. 14). Although such stands have some of the longest current fire intervals, many sites remain lightly stocked because of thin soils and inherently high drought stress (Steele et al. 1981). However, scattered thickets of Douglas-fir still produce high fuel concentrations locally. Long-term accretion of litter and duff can also promote lethal scorching of tree root crowns during fires, and surviving scorched trees often become vulnerable to insects and diseases (Barrett 1988, Arno et al. 1995). Additionally, fire exclusion has allowed trees to invade some previously unforested sites, reducing the size and vigor of those communities (Lunan and Habeck 1973, Barrett et al. 1991, Skovlin and Thomas 1995). Without repeated fires, for example, browse vigor and nutrient content has diminished (Freedman and Habeck 1985), and many shrubs have grown beyond the reach of browsing animals.

Repeat photography provides further evidence of widespread successional advances since 1900 in this region (figs. 15, 16). In the Blue Mountains of northeastern Oregon, for example, historical photographs combined with modern retakes show that many previously open stands and meadows have been invaded by trees in fire's absence (Skovlin and Thomas 1995).

The effects of fire exclusion have been more variable in the montane mixed conifer forest, such as in the larch-Douglas-fir cover type on north aspects. Many stands are still experiencing natural succession (fig. 17), but the fire exclusion map suggests that two-thirds of the stands in that cover type have current fire intervals well beyond the overall average MFI (fig. 11). Moreover, while most stands in the subalpine forest zone are still experiencing natural succession (fig. 18), most now have fire intervals that are longer than the 100-year long presettlement MFI. Fire exclusion alone did not

Fig. 15. Repeat photography in Blue Mountains, Oregon: PP/DF cover type (Skovlin and Thomas 1995).

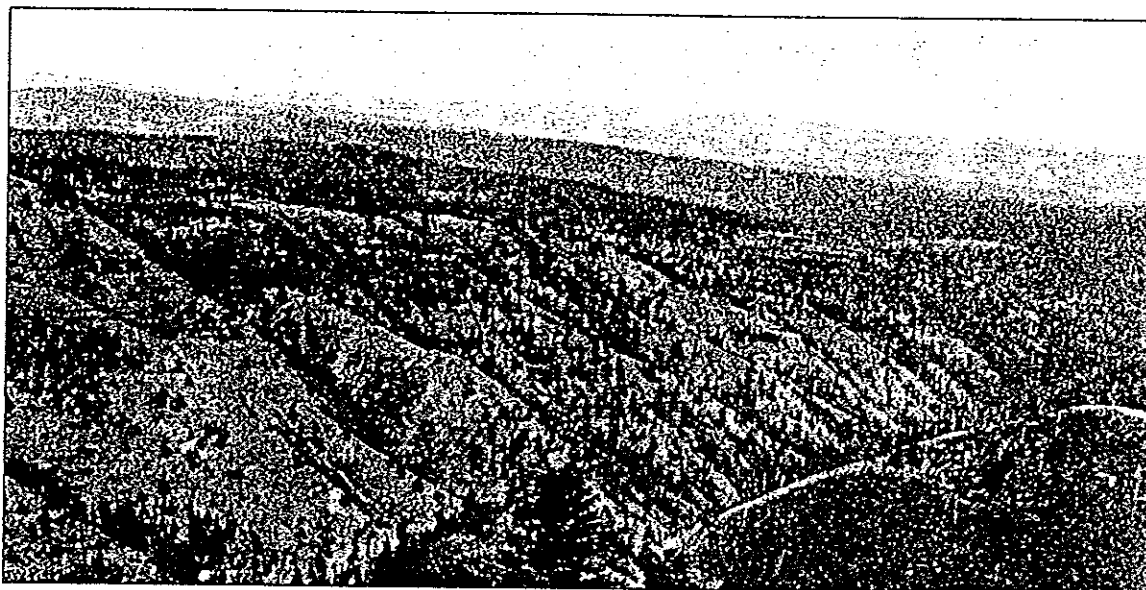


Photo by W.L. Dutton

Figure 19c—1924. The right-hand photo of the pair shows snags and irregular old growth on the timbered flat across the canyon. Note the pole-sized patch of regeneration just above the canyon breaks (upper left). Also, note the burned hillside at the lower right.

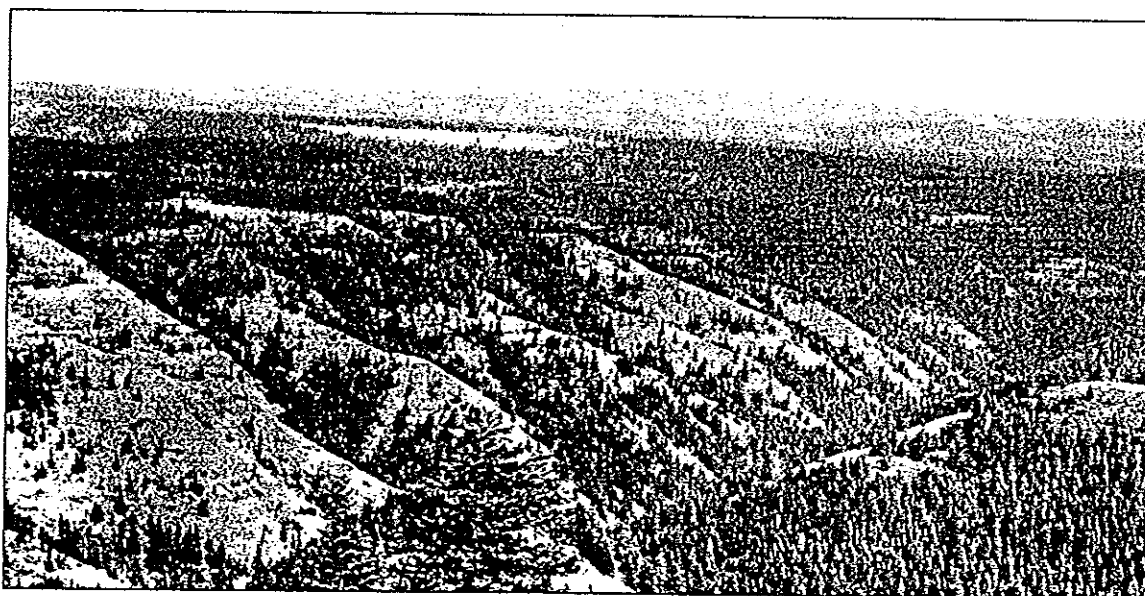


Figure 19d—1992. Logging has replaced the uneven-aged stands with even, well-stocked stands that are uniform and healthy in appearance. The burned hillside at the lower right has completely regenerated. Several clearcuts were visible from this overlook in 1982 (photo not shown). Eighteen are seen now; one appears to be in excess of 30 hectares.

Fig. 16. Repeat photography in Blue Mountains, Oregon: LPP cover type (Skovlin and Thomas 1995).

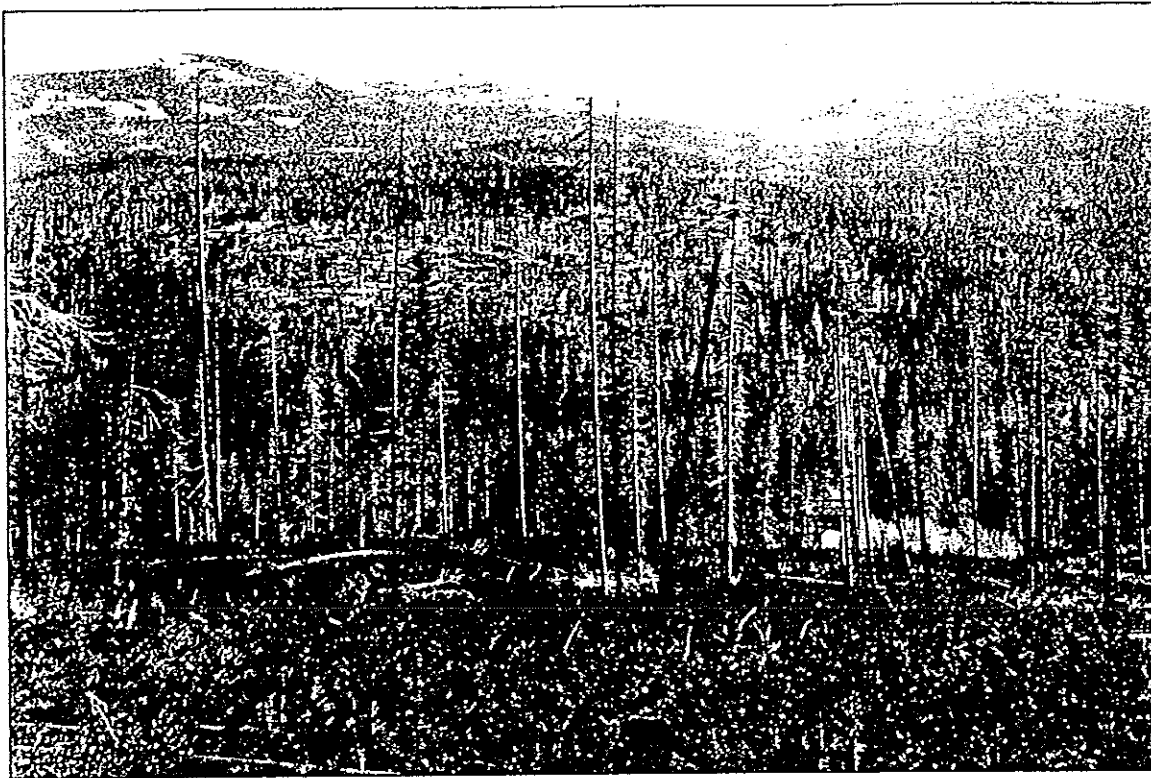


Figure 24a—1902. Ravages of the 1889 burn are obvious. Note lodgepole pine seedlings in foreground and a cluster of larch saplings (right). The ridge tops on the distant horizon are quite open.

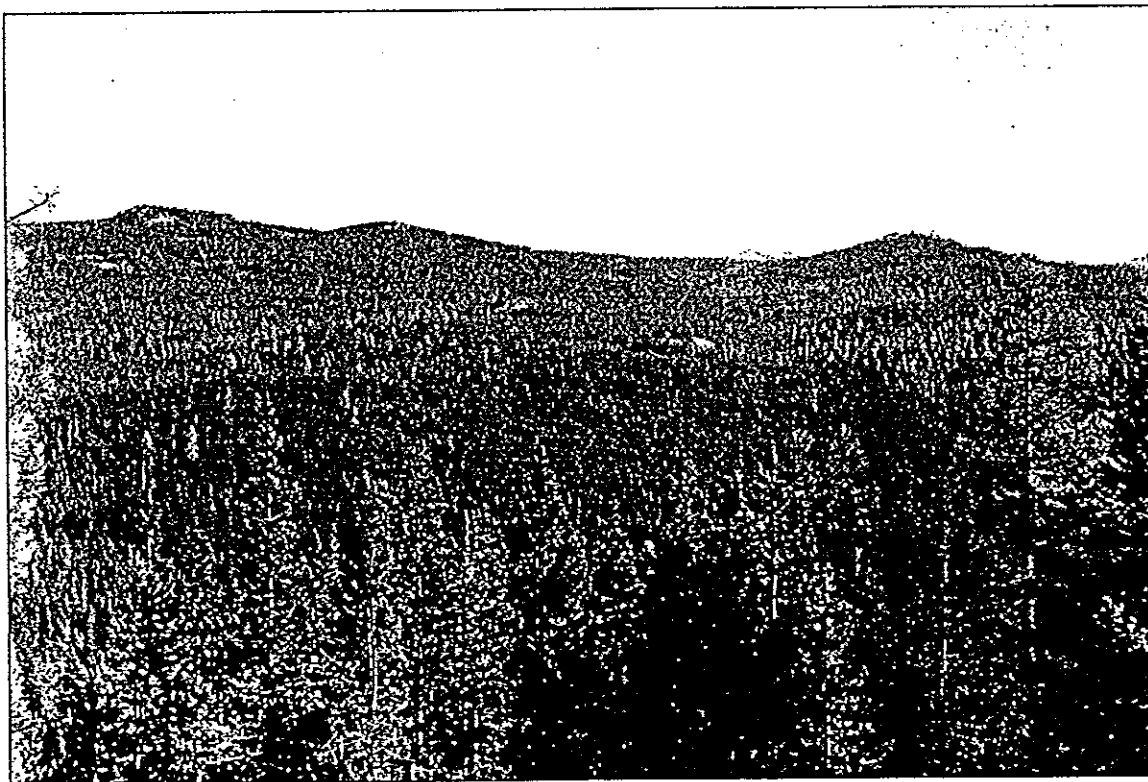


Figure 24b—1967. The new lodgepole stand is about 75 years old and the canopy has closed. Older larch that survived the fire of 1889 are prominent above the continuous canopy. Ridge-top openings have become overgrown with conifers.

Fig. 17. Successional Trends
WL-DF Cover Type (MS I Regime)

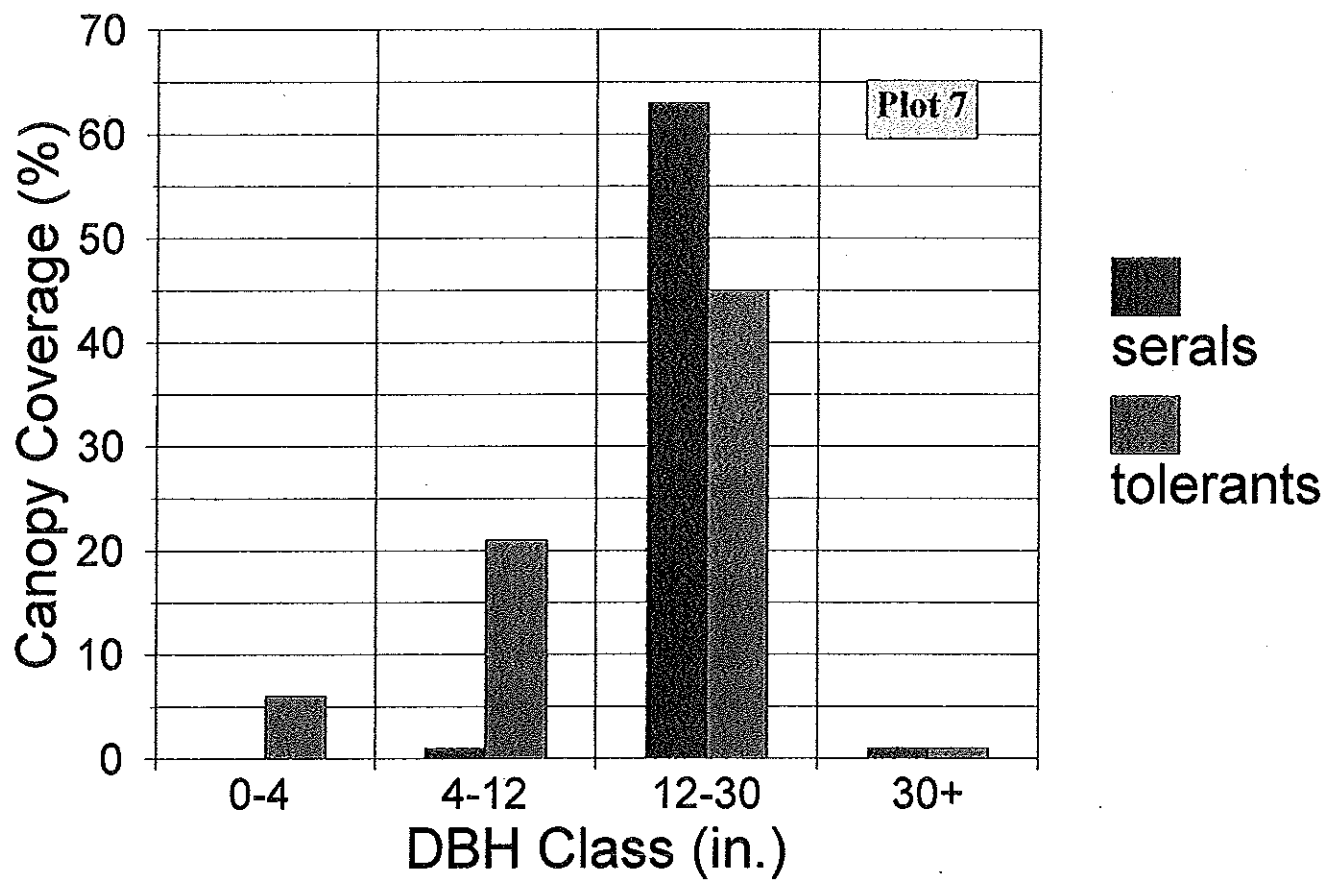
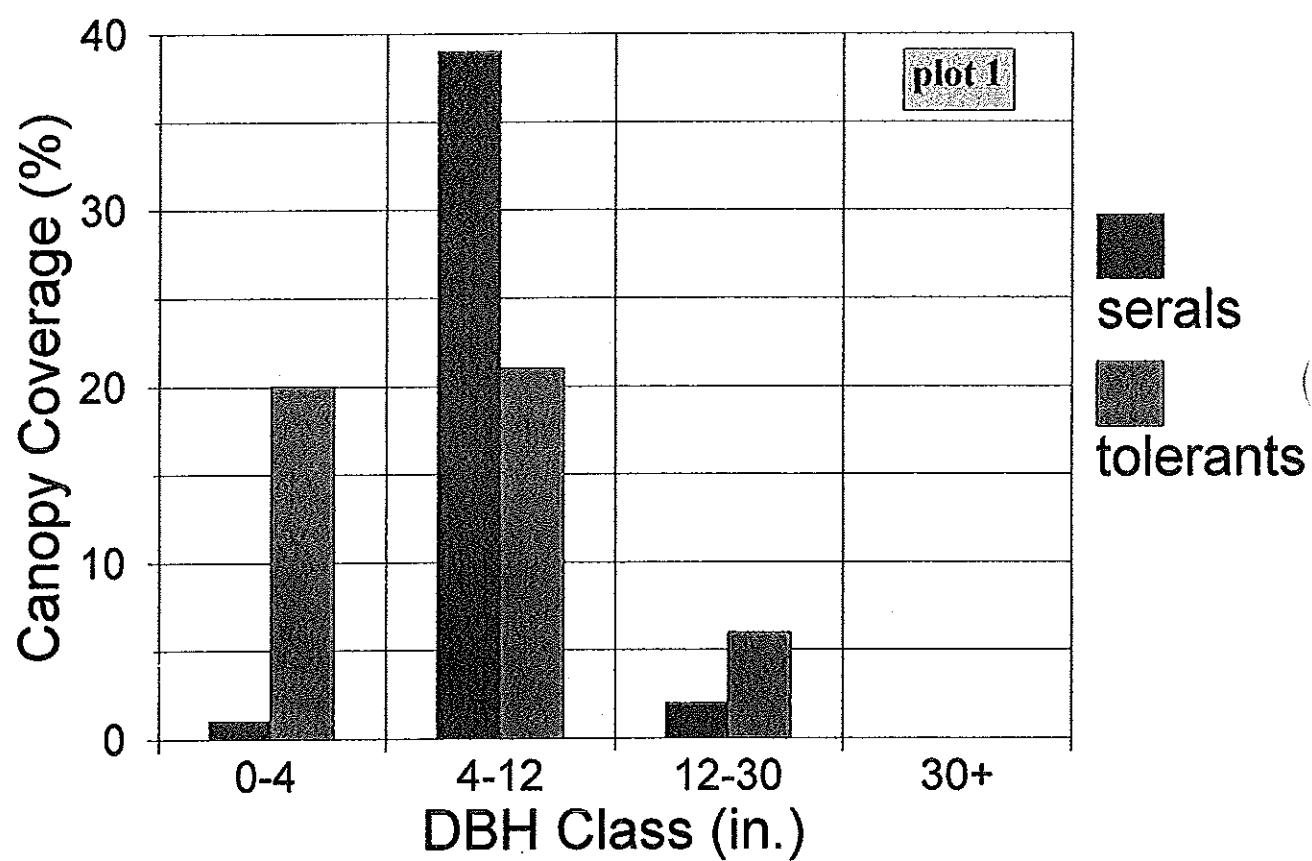


Fig. 18. Successional Trends
LP-DF Cover Type (MS II Regime)



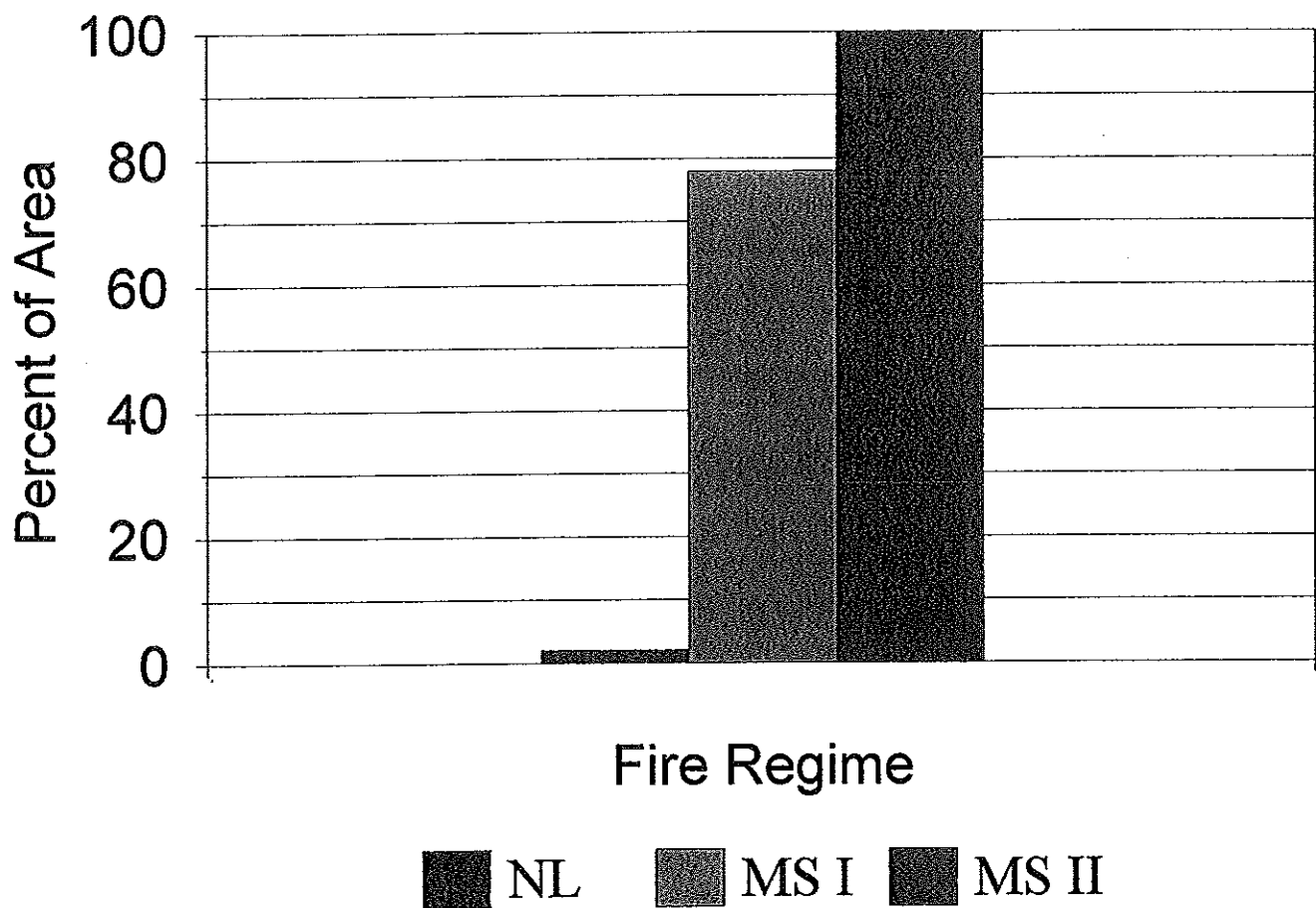
produce this result, but probably lengthened some intervals that had begun in the early- to mid-1800s. Regardless of causal factors, most mid- to upper elevation stands contain substantial fuel loads that are well able to burn — next to a heavily impacted ponderosa pine forest. Consequently, the study area might be vulnerable to wildfires of unprecedented size and severity, when compared with the presettlement patterns. This scenario is probable because aggressive fire suppression undoubtedly will continue to eliminate all but the most severe fires in the area (i.e., during worse than “average bad” conditions). In fact, recent wildfires in central Idaho (e.g., in 1994) have destroyed old stands on tens of thousands of acres in the Salmon River Ecosystem, Boise National Forest, and elsewhere.

In summary, although half the stands in the Papoose Allotment have fire intervals still within the range of natural variability (fig. 19), only 30 percent have intervals at or below the historic MFI. Virtually no stands in the nonlethal regime have fire intervals still within the range of natural variability, and only 30 percent of the stands that had mixed severity fires now have intervals at or below the historic MFI.

Implications for Management. Fire history research can be useful for planning ecologically-based forest management (Arno and Brown 1989, Mutch et al. 1993, Mutch 1994). For forest restoration, managers can use fire regimes information to identify and prioritize areas that could benefit from prescribed fire and fuels management silviculture. For example, data from sample stands and the fire exclusion maps suggest which stands have been the most heavily affected by fire exclusion, versus areas still experiencing natural succession.

Fire history data can be used in designing management activities that simulate past fire disturbance. For example, thinning harvests would be appropriate restoration treatment for stands in

Fig. 19. Fire Intervals Still Within
Range of Natural Variability.

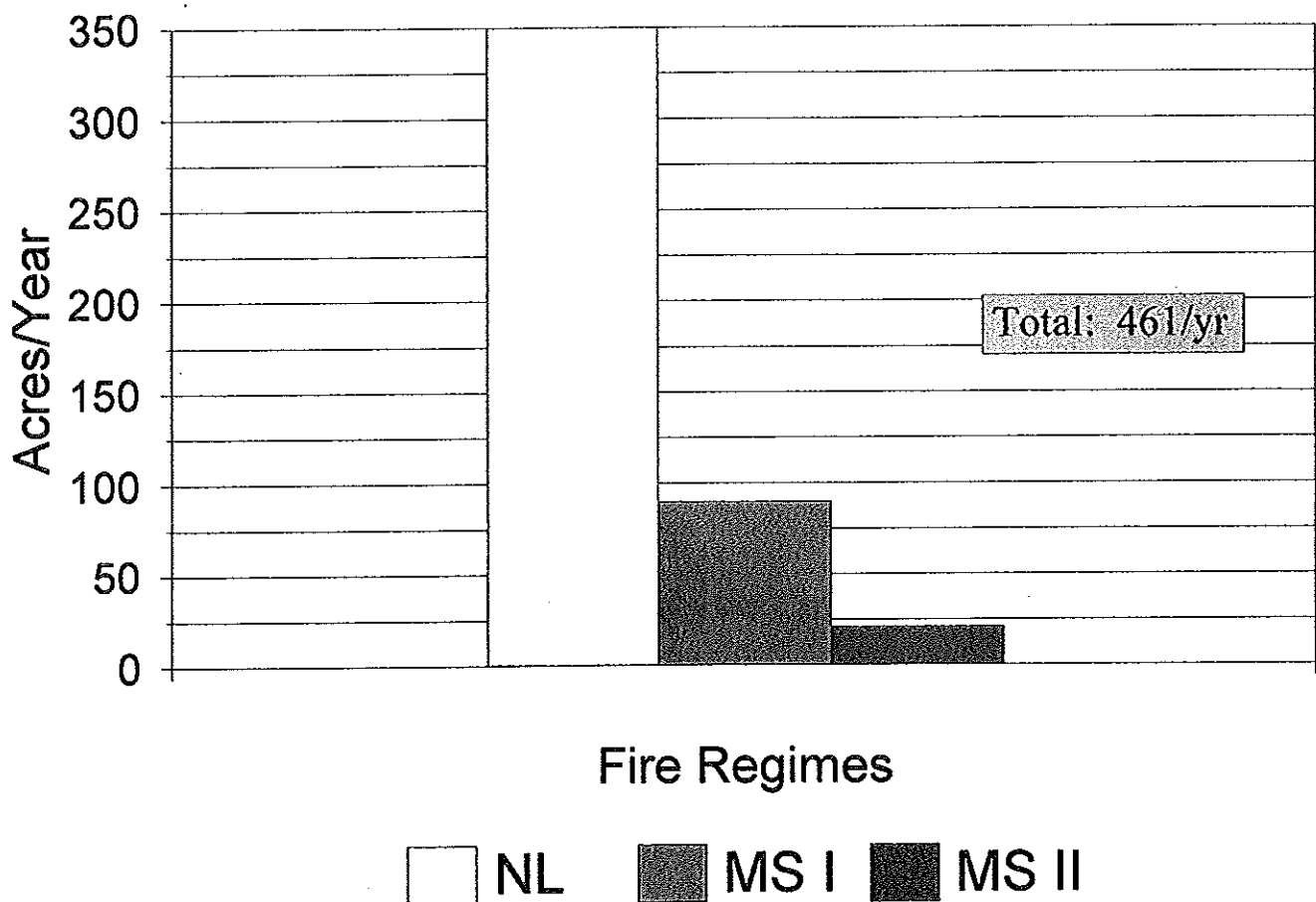


the nonlethal and mixed severity fire regime, and prescriptions could vary by forest type. Uneven-age systems, or prescribed fires, would be appropriate for dry stands in the ponderosa pine-Douglas-fir cover type. Prescriptions could incorporate an initial light- to moderate thinning of understory poles, followed by individual-tree selection during future entries (Arno et al. 1995). Post-restoration entries could be scheduled to replicate the past range of fire intervals (e.g., 10-30 yr). Conversely, prescribed fire alone might be sufficient for restoring a semblance of natural succession on lightly forested sites. In terms of maintenance burning, few lower elevation sites are still in balance with respect to the natural fire cycle. Nonetheless, manager-ignited prescribed fires would help diversify the mosaic, particularly in the mixed conifer- and subalpine cover types.

For mixed conifer stands with currently long fire intervals, such as in the larch-Douglas-fir cover type, an initial moderate- to heavy thinning of understory poles might help restore historical stand structures. To simulate low- to moderate severity fires, subsequent harvests could use various combinations of uneven and even age systems, depending on site type and stand variability. For instance, individual tree- and small group selection would replicate the effects of mixed severity fires on sites dominated by larch and Douglas-fir. Moreover, long-term prescriptions could incorporate silvicultural or prescribed fire re-entries to simulate the range of past fire intervals (e.g., 25-100 yr).

For landscape-scale planning, area fire cycles (Romme 1980) can help guide in scheduling and monitoring cumulative disturbance over time (fig. 20). Specifically, fire cycles can be calculated for each fire regime type by dividing the total acreage by the representative stand MFI. In the nonlethal fire regime, fires burned an average of about 350 acres per year (6%) of the 5500 total acres occupied by that type (i.e., 5492 acres divided by 16-year avg. MFI). Mixed severity fires burned an average of

Fig. 20. Mean Annual Acreage Burned
By Fire Regime Type, 1652-1936 A.D.



about 90 acres per year (2%) of the 4700 acres occupied by the montane mixed conifer cover type. Finally, mixed severity fires in the subalpine forest burned an average of 21 acres per year (1%) of the 2300 acres of lodgepole pine-Douglas-fir cover type. In sum, fires burned an average of about 461 acres per year in the study area, or, acreage equal to the total study area every 33 years. (Although few acres have burned since 1936, the study area theoretically would have burned *twice* during the past six decades). Accordingly, managers can use such information to monitor disturbance resulting from both natural and cultural sources, such as fires or fuels management silviculture.

SUMMARY

From at least 1652 to 1936, nonlethal and mixed severity fires were very frequent in the Papoose study area of the Salmon River Canyon. However, long-term fire exclusion by grazing and fire suppression has substantially disrupted area fire cycles, producing fundamental changes in lower elevation forests. At the stand scale, *species composition* has shifted in most ponderosa pine-dominated stands. Whereas pre-1900 stands were dominated by early seral species, shade tolerant species now dominate many fire-excluded sites. *Stand structures* have also changed. Tree densities in ponderosa pine stands have shifted from light- to heavy stocking, greatly increasing the level of tree competition and promoting stand decadence. At the landscape scale, the study area is experiencing *artificially induced mosaic homogeneity* (Romme 1982, Romme and Knight 1982, Barrett et al. 1991, Brown et al. 1994). That is, repeatedly extinguishing fires over the past eight decades has reduced forest age class diversity and, hence, landscape biodiversity. Besides posing a threat to the area's last remaining old growth stands, fire exclusion has thus reduced overall ecosystem integrity. And finally, *area fire hazard* is increasing, possibly threatening the wildland/rural interface.

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APPENDIX
Master Fire Chronology (*Year: No. Plots*).

20 th Century	19 th Century	18 th Century	17 th Century	16 th /15 th Centuries
1996: 2	1894: 1	1798: 9	1697: 6	1598: 2
1973: 1	1893: 1	1797: 3	1691: 3	1592: 1
1960: atlas	1892: 1	1796: 2	1689: 2	1575: 1
1959: atlas	1889: 32	1794: 1	1686: 8	1564: 1
1958: atlas	1886: 1	1790: 6	1679: 5	1554: 1
1949: 1	1884: 2	1789: 1	1677: 3	1548: 1
1948: atlas	1880: 2	1787: 4	1675: 1	1522: 1
1936: 3	1875: 3	1784: 18	1668: 3	1483: 2
1930: 1	1869: 34	1781: 1	1664: 4	
1926: 2	1866: 4	1776: 5	1660: 2	
1924: atlas	1863: 2	1775: 6	1656: 5	
1919: 4	1861: 1	1772: 9	1652: 2	
1910: 5	1859: 15	1768: 3	1642: 4	
1906: 3	1855: 10	1765: 3	1632: 2	
1904: 1	1852: 2	1762: 6	1625: 2	
1900: 1	1850: 1	1760: 1	1613: 1	
	1847: 23	1756: 12	1609: 2	
	1844: 10	1754: 5		
	1842: 7	1751: 3		
	1839: 2	1749: 2		
	1838: 2	1747: 3		
	1835: 21	1746: 5		

	1830: 8	1743: 2		
	1827: 7	1741: 5		
	1826: 7	1737: 2		
	1823: 3	1735: 1		
	1820: 3	1732: 11		
	1819: 3	1729: 3		
	1815: 19	1725: 5		
	1813: 10	1723: 2		
	1812: 7	1720: 2		
	1809: 3	1719: 5		
	1808: 7	1717: 1		
	1806: 1	1714: 2		
	1803: 16	1712: 3		
		1711: 2		
		1709: 2		
		1707: 6		
		1700: 6		

Master Fire Chronology: 1652-1936

Number of Fires: 95

Fire Interval Range: 1-7 yr.

Mean Fire Interval: 3 yr.

